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OPTIMAL CONVENTIONAL AND SEMI-NATURAL TREATMENTS FOR THE UPPER YAKIMA SPRING CHINOOK SALMON SUPPLEMENTATION PROJECT

Treatment Definitions & Descriptions &
Biological Specifications For Facility Design

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TREATMENT DEFINITIONS AND DESCRIPTIONS

and

BIOLOGICAL SPECIFICATIONS FOR FACILITY DESIGN

October 1999

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EXECUTIVE SUMMARY

This report prescribes the Yakima Fisheries Project facilities (Cle Elum Hatchery and acclimation satellites) which provide the mechanism to conduct state-of-the-art research for addressing questions about spring chinook supplementation strategies. The definition, descriptions, and specifications for the Yakima spring chinook supplementation program permit evaluation of alternative fish culture techniques that should yield improved methods and procedures to produce wild-like fish with higher survival that can be used to rebuild depleted spring chinook stocks of the Columbia River Basin.

The definition and description of three experimental treatments, Optimal Conventional (OCT), Semi-Natural (SNT), Limited Semi-Natural (LSNT), and the biological specifications for facilities have been completed for the upper Yakima spring chinook salmon stock of the Yakima Fisheries Project. The task was performed by the Biological Specifications Work Group (BSWG) represented by Yakama Indian Nation, Washington Department of Fish and Wildlife, National Marine Fisheries Service, and Bonneville Power Administration. The control and experimental variables of the experimental treatments (OCT, SNT, and LSNT) are described in sufficient detail to assure that the fish culture facilities will be designed and operated as a production scale laboratory to produce and test supplemented upper Yakima spring chinook salmon. Product specifications of the treatment groups are proposed to serve as the generic templates for developing greater specificity for measurements of product attributes. These product specifications will be used to monitor and evaluate treatment effects, with respect to the biological response variables (post release survival, long-term fitness, reproductive success and ecological interactions).

Biological specifications facilitate statistically valid experimentation by blocking treatment groups throughout all operational phases (broodstock holding, egg incubation, juvenile rearing, and smolt acclimation). Statistical blocking enables experimental application of treatments at any phase of fish culture from broodstock management through smolt release, as new uncertainty is identified through experimental results.

Production scale experiments, using two experimental treatments (nine replicates per treatment per year), compared over five year time frames, are described. All rearing and acclimation vessels are specified to accommodate experimental variables in a manner that facilitates random assignment of treatment groups to the vessels.

Some components of the fish culture facilities are defined, described, and specified according to physical features of other regional hatcheries in order to permit technology transfer of new concepts, procedures and methods to existing Columbia Basin facilities.

The two experimental treatments for the first five-year block compare the effectiveness of a state-of-the-art optimal conventional (OCT) rearing method to one form of semi-natural rearing method (SNT). Limited exposure of fish to SNT rearing methods may eventually be tested.

The OCT treatment sets the standard for all the controlled variables because prior research has demonstrated their efficacy. For example, release size was selected as a controlled variable because the relationship between size and survival is known.

Experimental variables were selected for research because: 1) they offer promise for increasing post-release survival and producing wild-like spring chinook salmon, and 2) only limited production scale research has been done on these variables. The experimental variables selected for research are: live foods, feeding

method, predator avoidance training, exercise, overhead cover, in-water structure, substrate, and sub-surface filtration.

The Semi-Natural Treatment (SNT) is a collection of experimental strategies for producing hatchery-reared spring chinook salmon that exhibit behavioral, physiological, and morphological attributes of their wild counterparts. It is assumed that wild-like attributes can be produced by rearing spring chinook salmon in semi-natural culture environments. The SNT culture environment consists of semi-natural raceways with high dissolved oxygen levels, overhead cover, in-water structure, and natural substrate, with live and pelletized food introduced below the surface. The SNT rearing environment is configured to promote exercise and predator avoidance conditioning. The expectation is that this semi-natural habitat will: 1) improve immuno-competence by alleviating environmental stress; 2) promote the development of natural cryptic coloration and anti-predator behavior; 3) increase foraging efficiency; and 4) reduce the genetic selection pressures induced by the artificial environment. Although founded on the best available scientific information, the SNT rearing environment is an experimental treatment with uncertainty and risk.

The success of these experimental rearing strategies will be determined by comparing the biological attributes of fish reared under SNT and OCT protocols with wild reared spring chinook salmon. These comparisons focus on those aspects of spring chinook salmon that the SNT experimental treatment variables are expected to affect. The expectations for OCT, SNT, and wild reared fish are expressed as a series of behavioral, physiological, morphological survival attributes.

In summary, treatment definitions and descriptions and their associated biological specifications are completed such that final project design can proceed. Treatment definitions, descriptions, and specifications set forth in this report are referenced and underlying assumptions, conclusions, and recommendations are stated.

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PREFACE

Supplementation of Upper Yakima Spring Chinook salmon stock is a major component of the Yakima Fisheries Project. Facilities will be constructed and operated to accomplish the project's experimental, natural production, genetic, ecological, and harvest objectives. Supplementation facilities for Upper Yakima spring chinook salmon include: (1) an adult collection and monitoring system at Roza Dam, (2) adult holding, incubation, and rearing facilities near the city of Cle Elum, and (3) acclimation/release ponds throughout the upper Yakima River drainage.

Facility planning for the Yakima Fisheries Project is a step-wise process in which key tasks in and along a "critical path" will be addressed, time-wise, toward facility construction and operation.

This report presents the following: (1) descriptions and definitions of experimental treatments planned for Upper Yakima Spring Chinook salmon supplementation research, and (2) biological specifications to advance scientific and biological requirements within the facilities design process. As such, it is a template for similar planning processes associated with other YFP stock alternatives (e.g., Lower Yakima Fall Chinook, and Marion Drain Yakima Fall Chinook, Lower Yakima Coho, Naches Summer Steelhead, etc.).

TREATMENT DEFINITIONS AND DESCRIPTIONS

TREATMENT DEFINITIONS AND DESCRIPTIONS

I. INTRODUCTION

The Yakima Fisheries Project (YFP) is designed to test the assumption that supplementation can be used to increase natural anadromous fish production and improve harvest opportunities while maintaining genetic resources and keeping adverse genetic and ecological interactions with non-target species within acceptable limits. This document will focus on upper Yakima spring chinook salmon, one of three genetically distinct chinook salmon stocks in the Yakima basin (Busack 1993).

Facilities will be constructed in the Upper Yakima River Basin to serve as a production scale laboratory to resolve critical uncertainties related to supplementation. Scientists will use this laboratory to evaluate the alternative fish culture techniques that can be used in supplementation programs. These evaluations will generate improved fish culture and release techniques that yield high survival of wild-like fish that is assumed to be needed for supplementation to contribute to rebuilding depleted wild salmon and steelhead stocks throughout the Columbia River Basin.

Naturally produced fish have or display a broad array of characteristics believed to be important indicators of pre-smolt and smolt status. These attributes (fish health, morphology, behavior, and survival) will serve as target specifications for monitoring and evaluating the effectiveness of artificial culture methods in producing fish with the appropriate wild-like characteristics (Table 1).

It is crucial that the facility be designed to scientifically resolve current and future critical uncertainties regarding the culture and release of fish for use in supplementation programs. Therefore, to provide the maximum statistical power in the most cost effective manner, the biological specifications require that the facility be planned so that treatments can be statistically blocked throughout broodstock holding, incubation, rearing, and acclimation phases. This will enable researchers to apply experimental treatments at any level of fish culture from broodstock management through release, as new critical uncertainties emerge.

The main value of the scientific information obtained from this facility over the next several decades is its adaptive management application to other programs within the Columbia River Basin. Therefore, the biological specifications require that certain aspects of the facilities (e.g., raceways) be designed in common with most of the other hatcheries. This will allow those concepts that are demonstrated scientifically to be valuable to be readily retrofitted to existing facilities.

The biological specifications define facilities in which two (2) experimental treatments can occur. At acclimation there are nine (9) replicate vessels/treatment. For this level of replication to be maintained in any given experiment, there must be nine (9) or more vessels/treatment available from the time the treatment is applied. Therefore to maximize experimental flexibility, statistical power, and facilitate fish handling the biological specifications must provide at least nine (9) incubation, rearing, and acclimation vessels/treatment. The design must also provide some capability to accommodate other research needs.

The project experimental design requires that each experiment be conducted over one life cycle. Thus with spring chinook salmon, the facility will be dedicated to comparing treatment effects over five year blocks. The first five-year block will compare the effectiveness of conventional rearing methods and semi-natural rearing methods for producing spring chinook salmon suitable for supplementation programs. The two treatments to be applied are Optimal Conventional Treatment (OCT) and Semi-Natural Treatment (SNT)(Fast 1992, BPA 1992). Experimental treatments will be applied to the particular study groups at the start of feeding and continued until the smolts leave acclimation ponds.

The Optimal Conventional Treatment is the experimental control that uses state-of-the-art artificial production techniques in incubation, rearing, and acclimation to raise and release fish (ibid.). The Semi-Natural Treatment is an experimental treatment that creates a more natural environment to rear and acclimate fish. The intent of this treatment is to raise and release fish that mimic the positive survival characteristics and behavior of their naturally produced counterparts (ibid.). A Limited Semi-Natural Treatment, an experimental treatment in which fish are subjected to state-of-the-art artificial techniques like OCT fish through raceway rearing and then subjected to a more natural environment like SNT fish during acclimation, may be considered in later phases of the project. This treatment would serve to determine if only limited exposure to a more natural environment is sufficient to induce the positive behavior and survival characteristics observed in naturally produced fish.

Table 1. Target biological attributes for upper Yakima spring chinook.

ATTRIBUTE	PARAMETER	MEASURES	SAMPLING INTERVAL (VARIES PER NEED)
FISH HEALTH	PHYSIOLOGY	Gill Na+/K+ ATPase	Mean = $x_{1..n}$ SD = $y_{1....n}$
		Thyroxine	“
		Cortisol	“
		Liver Glycogen	“
		Amine Competence	“
		Hematocrit	“
		White Cell Count	“
	PATHOGEN PREVALENCE	IHN Virus	“
		Erythrocytic Inclusion Bodies	“
		Renibacterium salmoninarum	“
		Ceratomyxa shasta	“
		Chondrococcus columnaris	“
		Aeromonas salmonicida	“
		Yersinia ruckeri	“
		Cytophaga spp.	“
	PARASITE PREVALENCE	Endoparasites	“
		Ectoparasites	“
	CONDITION	% Fat	“
		% Protein	“
		Protein:Fat Ratio	“
		Condition Factor (K)	“
		Eye Condition	“
		Gill Condition	“
		Fin Condition	“
		Parasitic Scarring	“
MORPHOLOGY	CRYPSIS	Dorsal Coloration Index	“
		Parr Mark/Total Body Index	“
		Parr Mark Darkness Index	“
		No. Dorsal Spots	“
		Lateral Iridescence Index	“

ATTRIBUTE	PARAMETER	MEASURES	SAMPLING INTERVAL (VARIES PER NEED)
	MORPHOMETRICS	Fork Length	“
		Standard Length	“
		Weight	“
		Truss Measurements (Index)	“
BEHAVIOR	MIGRATION	From Acclimation Ponds	“
		Sustained Swimming Speed	“
		Upstream/Downstream Movement	“
	HABITAT PREFERENCE	% Time Spent in Cover	“
		Distance from Bottom	“
		Distance from Structure	“
		Distance from Side	“
		Depth Preference	“
		Velocity Preference	“
BEHAVIOR	FORAGING PREFERENCE	#Test Prey/Taxon Consumed	“
	FORAGING EFFICIENCY	Prey Attack:Stalk Ratio	“
		Prey Capture:Attack Ratio	“
		Prey Ingestion:Capture Ratio	“
		Prey Acquisition/Unit Time	“
		Prey Handling Time	“
	FORAGING ABILITY	Total Contents/Weight/Stomach	“
		% Food Items (By Weight)/Stomach	“
		% Non-Food Items " "	“
	PREDATOR AVOIDANCE	Predator Recognition Index	“
		Predator Evasion Index	“
		Response Time:Cover Ratio	“
	GENERAL SOCIAL	Nips/Unit Time	“
		Displays/Unit Time	“
		Inter-Fish Distance	“
		Polarization Index	“
SURVIVAL	SUPPLEMENTATION FISH	Emergent Fry:Smolt Survival Rate	“
		Smolt:Smolt Survival Rate To Roza	“

Production Objective

The experimental design requires the production of 18 separate lots of 45,000 smolts for release as experimental groups into the watershed above Roza Dam (Table 2). These fish will be 15 per pound at release and, in total, weigh 54,000 pounds.

Table 2. Production requirements for Upper Yakima spring chinook salmon research (Y/KFP 1995).

No. of release groups	18
No. of smolts/group (approx.)	45,000
Total programmed for release	810,000
Release size (fish per pound)	15
Total pounds to be released	54,000

II. STANDARD TREATMENT METHODS

This section presents anticipated culture methods that will be applied to all experimental treatment groups from broodstock collection to the start of fry feeding. It also provides biological and operational criteria for associated fish culture and monitoring facilities.

A. Adult Collection and Monitoring

Adult spring chinook salmon will be trapped at Roza Dam and transported to Cle Elum Hatchery (ibid.).

The U. S. Bureau of Reclamation designed the Roza Dam adult collection facilities, and began construction in 1992 with a scheduled completion in 1993 (USBR 1992). The scientific basis for facility design
was provided in a memorandum (Easterbrooks 1991). Scientific requirements and specifications were:

- 6 holding compartments for fish segregation
  - 4 for holding 25 unsampled fish each
  - 2 for holding 50 sampled fish each
- Holding volume - 10 cubic feet per fish
- Minimum pool depth - 5 feet
- Sorting flume with mounted coded wire tag (CWT; Jefferts et al. 1963) detector equipped with auto-sorting instrumentation (operating procedures and protocols included)
- Crowding capability and "immobilization" brail to facilitate fish handling by use of plastic (pvc) tubes
- Bio-sampling work area including anesthetic tank, processing table, recovery tanks, and chutes for sorting fish that are either held or returned to the Roza pool
- Off-ladder holding pool and features, assuming a Denil fishway design

The minimum flow per adult requirement is 1 gallon per minute at 50°F (assuming a 15 pound/fish average weight) with the inflow adjusted at 5% per degree average water temperature departure from the standard (Senn et al. 1984). Flow must be provided so that the holding vessel outflow dissolved oxygen level is 7 mg/L or greater (ibid.).

The new adult trapping facility incorporates proven design features and is located on the left bank of the Yakima River (Roza pool) approximately 300 feet upstream of Roza Dam. It is hydraulically connected to the existing fishway by a flow control structure and a light-ported spiral-ribbed aluminum pipe which serves as a lake level fish transport channel (following Cowlitz Hatchery design). An intake provides a gravity source for the transport channel and a river water source, via pumps, for the trapping facilities. The head end of the transport channel is a collection area consisting of a "V" trap entrance, crowder, and a Bonneville-Hatchery style fish lock and lift. From the top of the fish lock, a fish sorting flume (Prosser Dam design) descends past four holding tanks and exits as a river return line. Access to each holding tank is provided by remotely or automatically controlled quick acting power gates. Holding tanks are provided with a crowder channel access port and individual crowders. The common crowder channel is provided with a crowder that is used to separate/crowd fish retained for hatchery transfer or for crowding to a fish-handling "scalloped" brail. A water-to-water fish transfer brail is used for lifting fish from the crowder channel and for fish transport truck loading.

Fish will ascend the Roza fishway and enter the trap via the transportation pipe. Trapped fish will be crowded into the fish lock that will subsequently be closed and flooded to the elevation of the fish sorting structure. A false floor (lift) will be raised to crowd the fish upward within the lock. Fish sorting will be managed by an operator controlling the lock and lift operation. Fish will have the opportunity to exit the lock volitionally over the false weir as flow is increased or will be otherwise encouraged to exit by the raising of the false floor which serves as a brail. The individual controlling the fish lock will also be responsible for either sorting fish (by species) into holding tanks, or directing fish to pass through and exit into the Roza pool.

Processing of collected adults will entail: (1) crowding from the holding tanks, (2) crowding to the head of the crowding channel, and (3) crowding via brail for handling adults. Handling will involve: (1) placing captive fish into plastic tubes (while on the brail) for control during anesthetizing, (2) examination for specific identifiers (tags, fin-marks, brands, etc.), and (3) other project-related sampling. Fish selected for hatchery use will, while anesthetized, be injected with an antibiotic before transfer to adult holding ponds at Cle Elum Hatchery.

Following Genetic Hatchery Guidelines (GHG), only naturally produced (non-marked) fish will be selected for hatchery use and no more than 50% of the available non-hatchery fish can be used for broodstock (Kapuscinski and Miller 1993; Y/KFP 1995). The adult population will be sampled such that the collected adults represent population parameters including arrival time, age, size, etc. (ibid.; Busack 1993a).

The project Planning Status Report (Y/KFP 1995) provides the experimental basis for the number of adult spring chinook salmon broodstock required to support the supplementation program. It will be necessary to collect and transport 1,110 adult fish (Table 3).

Fishway, trap, and transport pipe will be in continuous operation under gravity water flow, except per a BPA/USBR agreement related to winter operations (Appendix B). Adult collection and monitoring facilities requiring pumped water will be operated on a daily basis with no fish being held overnight.

1. Sorting & Enumeration

The facility operator will have the responsibility for operating the fish lock/lift and sorting flume gates. This person will discriminate the fish by species entering and passing down the sorting flume either to holding tanks or to the Roza pool. It is expected that electronic tag detection and automatic sorting devices will eventually be incorporated into the sorting process.

An assistant may be required to operate the trap crowder to haze fish into the lock chamber for holding until the access port is closed.

2. Biological Processing

Biological processing will involve anesthetizing (MS-222, 130-260 mg/L - Collinsworth and Moberly 1983), handling the fish as necessary to verify and record species, fish origin (experimental or "wild") by the presence of fish identifiers, and to further observe fish to assure appropriate broodstock collection.

Adults selected for hatchery use will be injected with an antibiotic during bio-processing. Adult mortality and juvenile disease related to bacterial kidney disease (BKD) is reduced by injection of an antibiotic, erythromycin. Treatment methodology presently involves injecting 20-30 mg/kg fish weight of "Erythromycin-200" into the dorsal musculature (Harrell 1993; Moffitt et al. 1993).

3. Broodstock Acquisition

Returning adults will be sampled to assure that fish selected for broodstock are representative with respect to time of arrival, age, size, sex-ratio, etc. (Busack 1993a; Kapuscinski and Miller 1993). Fish taken for hatchery broodstock will be transferred to adult holding facilities the day of collection.

<u>Fish Transportation - Adults</u>

Fish transport support will be accomplished by a combination of large and small equipment for an estimated 150 96-mile round-trips. Tank trucks, tank bearing utility trucks, and truck/trailer combinations are routinely used to transport salmon and steelhead adults at public fish production facilities.
The adult transport tank loading rate is 1.0 pound of fish per gallon at 50°F. Generally, loading should be decreased as temperature increases above 50°F and should be reduced by 10% for each degree of increased temperature above 60°F (Bell 1990). The loading rate can be increased by up to 30% for short hauls. Tempering is required where temperature differences between tank and receiving water exceed 10°F (note: the change upward has the greatest potential for reducing survival of transported fish). Ice used for tempering must be free of residual chlorine (Bell 1986).

Oxygen will be provided using liquid or gaseous oxygen and ceramic or carbon rod diffusers. The rate of oxygen delivery at 10°C of 3 Lpm (@ 80 psi per 1 meter carbon rod normally supports up to 550 pounds of fish (Weydemeyer 1992). Other transport tank features will include electrical agitators for recirculation, insulation for temperature control, water level sight gauge for volumetric measurement of loaded fish, and oxygen delivery controls and monitoring system to assure proper tank conditions (OPTT 1992).

Adult fish will be transported by tank to Cle Elum Hatchery adult holding ponds. The transport tank will be discharged via a rear-located spring-loaded gate. Considering the characteristics of the adult holding vessels, the tank contents (adult fish) will be released via a flume to direct fish away from pond walls and bottom. Flumes are commonly used for this purpose.

B. Broodstock

1. Adult Holding/Handling

A maximum of 1,110 Upper Yakima spring chinook salmon adults is required to be collected at Roza Dam and transported to Cle Elum Hatchery for spawning retention (Table 3). The assumptions used to derive the preliminary estimate of the numbers of broodstock are: egg to smolt survival - 65%, adult mortality - 20%, and eggs per female - 4,300 (BPA 1990). The mean fecundity estimate has subsequently been revised downward to 3,500 eggs per female (Knudsen and Busack 1993).

Table 3. Egg and broodstock requirements.

Smolts to be released	810,000
Eggs required (assumed 65% egg to smolt survival)	1,242,000
Eggs per female	3,500
Females required (assumed 20% mortality)	444
Sex ratio (male:female)	1.5:1
Adults required	1,110

Holding Volume

The adult spring chinook salmon holding volume is 10 ft^3 per adult following the design standard recently implemented at upper Columbia basin projects, such as Eastbank and Methow hatcheries (Scribner 1993). A minimum volume of 11,100 ft^3 of adult holding space will be required to retain adult fish from collection to spawning.

Two adult holding vessels are required to provide operational flexibility and the opportunity for retention of broodstock separately by experimental treatment (e.g., OCT, SNT).

Inflow

The minimum inflow requirement for adult spring chinook salmon holding is derived from the criteria of 1 gallon per minute, at 50°F, per fish (Senn et al. 1984). The inflow is adjusted at a 5% rate per degree of average water temperature increase from the 50°F standard (ibid.).

Water Quality

Adult holding success is dependent upon water quality. Water quality must be sufficient for adult holding in terms of water chemistry, pathogens, and temperature. The availability of pathogen-free water, typically from groundwater, can enhance adult holding by reducing mortality and, correspondingly, the number of broodstock required to support the supplementation program.

Project water quality standards determine the fish culture utility of potential/candidate Cle Elum Hatchery water sources. Results of biological studies and water quality analyses indicate that characteristics "appear quite suitable for fish production" (Dauble and Mueller 1993). In addition, water quality information summarized by Dauble (1993) indicates fish culture suitability of water sources where upper Yakima River acclimation sites may become established.

With respect to dissolved gases in groundwater, it is recommended "that waters be stabilized before use in a fish hatchery if the dissolved oxygen is less than 90% saturation, or if the dissolved nitrogen is greater than 102% saturation" (Senn et al. 1984). Ideally, the total gas saturation should not exceed 100%.

Concern exists as well for the presence of supersaturated gas in surface water. This is of particular importance in the case of upper Yakima River facility planning since nitrogen supersaturation was measured in the Cle Elum River in 1993 and was known to cause losses of captive fish below Cle Elum Dam (Harrell 1993a). Colt et al. (1991) reported reduction of the impact of surface water gas supersaturation in hatchery water supplies through the use of degassing structures.

In anadromous fish culture, process water that has been used for rearing a single group of juvenile fish (first-pass) is generally accepted as an alternate adult holding water source if pathogen, chemical, and temperature requirements are met. Such water may require aeration in order to re-establish dissolved oxygen levels sufficient to allow maximum inflow loading (1 adult per gallon per minute at 50°F.). Alternatively, flow must be increased to maintain dissolved oxygen levels if aeration is not provided.

The YFP has accepted the use of 2nd or 3rd pass water for adult holding for facility design purposes when constrained by water availability (BPA 1990). However, only 2nd pass water is recommended for spring chinook adult holding use .

<u>Water Temperature</u>

The recommended adult salmon holding temperature range is 43°F (Leitritz and Lewis 1980) to 55°F (Piper et al. 1982; OPTT 1992a).

In nature, adult spring chinook salmon ascend rivers, select and hold in environments of their preference and generally spawn in water temperatures ranging from 42°F to 51°F (Bell 1990). Stuehrenberg (NMFS, personal communication) indicated that radio-tagged spring chinook salmon holding in the upper Yakima drainage is commonly associated with dense cover (woody debris, primarily) but that associated temperature data on adult holding areas have not been gathered. In another Yakima River study, Berman and Quinn (1991) observed behavioral thermoregulation in which spring chinook salmon adults maintained
an average internal temperature of 2.5°C below ambient river temperature.

<u>Fish Health</u>

Several diseases occur in adult salmon and will probably occur in fish held for broodstock. The most prevalent external and internal diseases are discussed below.

Fungus: Fungus (*Saprolegnia sp.*) is expected to be the most prevalent external disease of adults at Cle Elum Hatchery. This disease is a secondary invader of external lesions, abrasions, and external bacterial infections and is a common factor in mortality of salmonid broodstock.

The contemporary treatment practice involves the use of a formalin (37% formaldehyde) "bath" in which fish are regularly exposed to the chemotherapeutant for a prescribed period. Harrell (1993) indicated that fungus control in spring chinook salmon held at the Washington Department of Fisheries (WDF) Hupp Springs Rearing Facility was realized with a 1:6000 treatment applied every other day from ponding until the adult fish showed obvious signs of sexual dimorphism. Safe application of formalin will require the use or construction of a distribution system that meets workplace safety standards (State of Washington 1992) and prevailing fire codes. In addition, proper storage for formalin must be provided on site.

Bacterial Kidney Disease (BKD): BKD is caused by a ubiquitous systemic bacterium (*Renibacterium salmoninarum*). Under some conditions, this disease can cause extensive mortality in salmon broodstock. The disease may also be transmitted from infected female salmon (via eggs/ovarian fluid) to offspring.

As noted previously, adults selected as broodstock will be injected with erythromycin at Roza Dam during biological-processing activities. They will also receive a second such treatment before being spawned. These injections should minimize adult mortality due to BKD and may mitigate vertical transfer (parent to offspring) of the disease.

Ceratomyxa: Research of project Fish Health Specialists has shown the presence of the protozoan *Ceratomyxa shasta* in returning salmon, however, to date the organism has not been found in juvenile salmonids held in liveboxes or recovered from migrants sampled at Prosser Dam (Harrell and Snell 1992). Currently, the organism is not expected to pose management problems.

Others: Parasitic copepods (Anchor Worms) of the genus *Lernea* have been found on most maturing spring chinook salmon observed in the Yakima River (Harrell and Snell, 1993). These parasites have been reported to predispose adults to *Saprolegnia* and/or cause additional stress on adults held for broodstock (Phyllis Barney, USFWS, pers. comm.). There is no known treatment for anchor worms at this time, however, treatment options will be investigated if these copepods pose a threat to adult survival.

Monitoring: A technical support room will be provided for diagnostic/routine fish health monitoring activities as well as other project-related research activities.

Physical Features

The facility design will include physical features that minimize the mortality of adult spring chinook salmon held as broodstock and consequently the number of fish to be removed from the natural spawning escapement.

The construction of an upwelling process water supply, overhead spray, and provision of features which otherwise eliminate loss through jumping or injuries are required (Senn et al. 1984). Water upwelling reduces a tendency of adults to jump and the overhead spray serves to act as a cover, possibly refracting light. These features are incorporated into adult holding ponds of the recently constructed Snake River and upper Columbia salmon hatcheries (e.g., Lyons Ferry and Eastbank).

Flexibility will be designed into the holding and fish handling facilities such that two primary groups of adults can be held separately and handled with minimum stress. External tags might be applied as the fish are collected at Roza Dam to provide the basis for broodstock research including the opportunity to assess time related differential mortality.

Illumination required for security will only be used as necessary to accomplish tasks safely. Otherwise, fish held within the adult holding vessels should not be influenced by artificial illumination so that spawning is not delayed by inadvertent photoperiod extension.

<u>Biological processing</u>

Biological processing of maturing adult spring chinook salmon requires the handling of live fish for injection, and testing for maturation. Fish in spawning condition will be killed within the pond, and removed for disinfection following NMFS sockeye handling methods (Flagg et al. 1991).

A specialized area will be provided adjacent to the adult holding vessel(s) for the completion of pre-spawned fish handling. This area shall also provide containment of killing-related waste (blood, mucous, wash-down water, disinfectant) (State of Washington 1990).

2. Spawning/Mating

Mature fish will be taken from the adult holding area following sorting/killing to a designated area (refer to biological -processing Area, below) for spawning, mating, and sampling necessary to support fish health, genetics, and long-term fitness monitoring and research.

Disinfection procedures will be implemented to minimize the potential for the spread of pathogens during transfer of fish from the adult holding ponds to the spawning area. Iodophor solution of 100 ppm provides general disinfection with a 5 minute exposure (Collinsworth and Allee 1988).

<u>Spawning</u>

Eggs will be removed from females using the incision method (Leitritz and Lewis 1980) with eggs and ovarian fluid retained together. Eggs and sperm (milt) from individual spawners will be placed in separate containers.

As necessary, gametes will be stored to prevent or minimize change from the ambient water temperature prior to fertilization. Troughs or refrigerated storage will be required to retain the gamete containers until fertilization. It is assumed that this gamete retention will be of short duration, not exceeding one hour.

<u>Fertilization</u>

Fertilization will take place before container transfer to a disinfection room to reduce the extent to which containers and personnel must be disinfected (Carl Ross, Lyons Ferry Hatchery Manager, personal communication, 1993). Use of a similar approach to transfer samples to the technical support room will also be used to reduce or eliminate disinfection of foot traffic to and from the building.

<u>Mating</u>

Mating will be randomized with respect to phenotypic traits, including size, within each group of adults which are ripe on the day of spawning. The mating scheme will follow Hatchery Genetic Guidelines (Kapuscinski and Miller 1993).

Biological Processing Area

A biological or "bio-processing" area will be provided for research and fish health support activities (OPTT 1992b). The purpose of this area is to make the research and fish handling efficient, and worker-friendly, and to manage activities so that data accuracy is assured. Lifting will be minimized and should only be necessary for removal of carcasses from racks during spawning. There will be no requirement for lifting from the deck, except the necessity to place the killed fish onto racks. Post-spawn processing will occur on a table with the carcasses slid from work station to work station and eventually transferred to leak-proof plastic bins ("totes") as the processing is completed.

The bio-processing area will serve the following functions:

- Technical Support Fish Identification: Individual fish will be assigned a unique alphanumeric identifier that will support research/fish health activities. Multiple-part forms may be used to tabulate data derived during these activities (ibid.).
- Spawning: Identifiers will be applied to the individual gamete containers.
- Mating: Mating procedures will follow Hatchery Genetic Guidelines (Kapuscinski and Miller 1993). Gamete container identifiers will be integrated to provide the genetic history of the pairing.
- Pathogen Characterization: Cavity fluid will be sampled as eggs are removed and other appropriate tissues will be excised after spawning for the detection of infectious diseases (e.g., virus and BKD). Samples will be matched, by label, to individual incubation units. Results of the tissue analyses may determine the disposition of individual egg lots and influence fish health management practices.
- Genetic Sampling: Samples of heart, eye, liver, and muscle tissues will be taken for electrophoretic and other genetic analyses.
- Morphometric Measurement: Morphometric work involving length and weight measurements will occur during bio-processing. Some of this work may precede spawning procedures.
- Fish Identification: Coded wire tags, PIT tags (Prentice et al. 1990), and other identifiers may be present in broodstock; therefore it will be necessary to keep the adults separated from the spawning process until the identifiers can be discriminated for proper matings to occur.

Biological sampling will require use of an adjacent working area (technical support room) for related information management, sample processing and storage, tag recovery and identification, other miscellaneous work, and technical equipment storage.

Carcass Handling and Storage

Spawned carcasses held in totes will be loaded onto trucks by fork lift or a tractor equipped with lifting tines. Carcass disposal will be consistent with state and federal regulations and project policy.

An area will be provided for daily storage, cleaning, and disinfection of totes. This area will also be used for equipment disinfection.

C. Incubation

Two systems, isolation-buckets (Novotny et al. 1984) and vertical incubators (Senn et al. 1984) will be used to incubate spring chinook salmon eggs at the Cle Elum Hatchery. Wells will provide pathogen-free process water for incubation (BPA 1990). Spring chinook salmon eggs will be isolated from fertilization through the eyed stage to allow for disease certification (CH2M-Hill 1991). Incubation will occur under dark or low-light (working) conditions. Filament lighting in the incubation room is preferred to fluorescent lighting (Bell 1990).

Egg development during incubation will be controlled through using chilled water after development to the 128 cell stage (Combs 1965; Tang et al. 1987). This provides flexibility to mimic natural conditions (BPA 1990). Managing the incubation temperature also accomplishes several objectives: (1) it regulates the number of days reared prior to transport to acclimation pond, (2) it allows growth control aimed at preventing the fish from attaining a larger than specified size, and (3) it provides opportunity to reduce the time between group ponding, and (4) it facilitates feeding of all fish through water temperature management.

Agency pathologists, per interview, (Hager 1991), preferred a facility design which provided the following:

- Isolation of incubating groups (species). The best-case design would provide separate rooms, not rooms partitioned with moveable curtains. Each room would be separately ventilated to further reduce risk of air-borne disease transfer and include other sanitation features.
- Use of isolation buckets for retaining fertilized eggs, by female, in summer chinook salmon, spring chinook salmon, and summer steelhead. This concern is driven by diseases that may be present in the adults and transmitted via gametes.

1. Disinfection and Water-Hardening

A disinfection (sanitation) room will be provided for post fertilization disinfection and water-hardening processes to increase protection from horizontally and vertically transmitted pathogens and to help control the spread of infectious agents within the incubation facility.

Fertilized eggs will be transferred from the bio-processing area to the disinfection room. Eggs will be dipped for 5 seconds in 100 mg of active iodine per liter of pathogen-free water prior to placement into iso-buckets for 1 hour water-hardening in 100 ppm iodophor to maintain the desired 100 mg/L concentration of disinfectant (Chapman and Rogers 1990). After one hour in iodophor, pathogen-free water will be circulated/introduced to the containers to rinse disinfectant from fertilized eggs. Following water-hardening, iso-buckets will be transferred to the incubation room.

<u>Isolation Bucket Incubators</u>

Iso-bucket incubation capacity will be provided equal to the number of females to be collected and retained for spawning (444).

The incubation system uses a down-welling water supply and a pair of nested buckets. Eggs are retained in the upper (inner) bucket and flow is introduced at the top of the bucket and exits downward through a screened bottom. Water level is controlled by ports cut near the top edge of the bottom bucket that serves as a "trough" for the egg bucket. Water will be delivered through mist nozzles at a rate of 18 gallons per hour (Public Utility District NO. 1 of Chelan Co. WA. 1988).

2. Incubation Through Eyeing

Water-hardened eggs in iso-buckets will be transferred to the incubation room for isolation of spring chinook salmon eggs. The iso-buckets will be placed into troughs that will be used to control wastewater.

Eggs will remain isolated by bucket until they reach the eyed stage and the parents have been characterized for important diseases (bacterial kidney disease, viruses). Chinook salmon eggs will have accumulated approximately 450 temperature units at eyeing (Senn et al. 1984).

Chemical treatment will be necessary to control fungus. Formalin is the only effective chemotherapeutant available presently but other agents are being actively investigated and may be available in the future.

Eyed eggs will be physically shocked (Leitritz and Lewis 1980) and allowed to stand overnight before removal of undeveloped or infertile eggs("picking"). Picking and enumeration tasks will be accomplished by a mechanical egg sorter (ibid.).

3. Eyeing Through Emergence

Vertical incubators will be used for the final phase of incubation to facilitate genetic research with up to 50 individual families (Busack 1993a). Hatching fry will be provided substrate within trays (BPA 1990). While there are several alternatives, the shallow tray incubation substrate of choice is heavy plastic netting which is folded and retained in four layers to fit within the trays (Fuss and Seidel 1987).

Following shocking and removal of dead eggs, eyed eggs from each iso-bucket (mating) will be placed into vertical incubator trays that will be arrayed in two stacked 8 tray cabinets as a "stack". In normal production use, each tray has a carrying capacity of 5,000 eggs and each 16 tray stack is provided with up to 10 gallons per minute (gpm) (Senn et al. 1984). The minimum incubator stack requirement is 24 - 18 for the planned release program and an additional six for family group research (Hopley 1995).

At swim-up, fry will be transferred by pipe or by tray to rearing vessels with the actual ponding date determined by visual observations, condition factor, or ventral slit measurement (Fuss and Seidel 1987). In the latter case, fry are to be ponded when the ventral slit has closed to 1-3 mm in width.

Monitoring flow and temperature of incubation process water is mandatory.

<u>Fish Health</u>

Bacterial Kidney Disease (BKD) and IHN Virus: Egg takes from mating pairs with positive indication of virus will not be destroyed automatically but will be managed as necessary, including possible isolation of high titer groups.

<u>Indoor Rearing</u>
Fifty troughs will be required for the indoor rearing of family groups for genetic research (Busack 1993a). The troughs will have sufficient volume to rear each group (assuming a maximum of 5,000 fish)

to a size large enough for application of coded wire tags and fin-marks (approximately 200 fish/lb). Initial studies will require 30 troughs provided with temperature regulation and monitoring (Hopley 1995). Temperature regulation will allow coordination of test group growth rates with their counterparts held in raceways.

The rearing density index will be .125 lb/ft^3/inch of body length (BPA 1990). Assuming an average length at marking of 2.52", maximum rearing density will approximate .32 lb per ft^3. The volume requirement per group is 63.3 ft^3.

The maximum inflow loading rate is 2 lb/gpm. It is approximately one-half of the recommended value cited by Piper et al. (1982) for chinook and coho salmon at 50°F because of handling and marking stress-related considerations. Accordingly, the maximum flow requirement per trough will be 10 gpm. (Note: This quantity is only partially additive to the total flow requirement for the facility since vertical incubator flow will be available in 10 gpm increments for use as fry are ponded.)

III. EXPERIMENTAL TREATMENTS - FISH REARING

Spring chinook salmon juveniles will be reared under a variety of conventional and experimental conditions (treatments) in hatchery vessels and acclimation ponds. The following discussion encompasses aspects of both experimental and controlled variables (those common to all treatments) to be applied to OCT and SNT treatment groups.

A. Optimal Conventional Treatment

1. Hatchery Rearing

The spring chinook salmon production goal of the Cle Elum hatchery is 810,000 spring chinook smolts weighing 54,000 pounds (Table 2). The production population will be separated into 18 groups, nine of which will be reared under the Optimal Conventional Treatment (Hoffman et al. 1995; Hopley 1995a). The OCT fish will be reared under conditions in the hatchery and at off-site acclimation ponds that are expected to produce the highest quality and most fit hatchery fish.

Prior to the end of their rearing cycle (approximately one year post swim-up), all experimental groups will be transferred to off-site rearing ponds for acclimation and release (BPA 1990). This transfer will occur in January to assure their presence at the release site before the increase in thyroxine and other physiological indicators associated with smoltification (and effective homing)(Maynard 1993 and 1993a).

By the end of the hatchery rearing cycle, OCT groups will have essentially attained their maximum size per fish (15 fpp) (BPA 1990, Senn 1993). The planned size at release is within the range of release size criteria common throughout the region (Hopley 1993; Scribner 1993a; Maynard 1993b).

<u>Rearing Density</u>: controlled variable (applied to all treatments)

The maximum rearing density is 0.75 lb/ft^3 of rearing space following the chinook salmon yearling rearing standard adopted for the design of upper Columbia basin facilities including Eastbank Hatchery (Public Utility District NO. 1 of Chelan Co. WA. 1988). Maynard (1993c) summarized the results of spring chinook salmon rearing density experiments showing survival and contribution advantages provided by lower than normal pond loading rates.

<u>Rearing Vessel</u>: controlled variable

By definition, OCT rearing vessels should represent the current Pacific salmon production standards in length, width, depth, and inflow. Raceway vessels typically conform to a ratio of 30:3:1 for length, width, and depth, respectively (Piper et al. 1982).

Following a literature review and a review of the PDR, Maynard (1993d) concluded that the recommended length and width were common to current design but the depth of 5 feet as represented in the PDR (BPA 1990) was non-conventional. He further concluded that water depth should be maintained at about 3.0 feet. The experimental design will assume a raceway design standard of 100' x 10' x 3.5' (operating depth) as the optimal conventional treatment in keeping with the Lyons Ferry raceway dimensions and current WDFW design.

Raceways will be installed as separate but adjacent units. Standardization of vessels is a critical factor needed to reduce experimental variation among the vessels. Maynard (1993e) provides the experimental rationale for the arrangement of vessels on-site.

Vessels will, for experimental flexibility, be dividable into four equal sections and will have infinitely variable water level control. Surface skimming is required to maintain proper fish health and will be provided by two surface level overflow weirs.

<u>Inflow</u>: controlled variable

Flow will be provided as necessary to maintain a high level of dissolved oxygen (not less than 7 ppm) at the outflow (BPA 1990). In particular, raceways will be supplied with 1.44 cfs (650 gpm) through a pond-width manifold following current WDFW facility design. In addition, outlet screens will also span the width of the vessel.

The fish growth model provided in the PDR (BPA 1990) uses a variable temperature profile with constant temperature from May into September for spring chinook salmon culture. Accordingly, two water supplies will be required for the culture of spring chinook salmon at Cle Elum Hatchery: (1) a production quantity surface water source to provide a fluctuating environment (water quality and temperature) needed to properly induce smoltification, and (2) a groundwater system to support production during the summer when surface water temperatures exceed the desired range for spring chinook salmon production.

<u>General Fish Culture</u>: controlled variables

The objective of the fish culture program is to produce high quality fish. The program will follow or modify standard practices that will be detailed or specifically referenced in facility and operations manuals.

The project will rely heavily on the collective fish culture experience of management agencies, individuals, and on current salmonid culture literature including Leitritz and Lewis (1980), Piper et al. (1982), Senn et al. (1982), Wood (1979), Fowler (1989), and Collinsworth and Moberly (1983).

<u>Fish Feed/Diet</u>: *experimental variable*

"The health and well being of artificially reared fish is directly correlated with proper nutrition and feeding" (Fowler 1989).

Fowler (ibid.) summarized general nutritional recommendations, quality control, and feed-related management practices. Specific spring chinook salmon nutritional requirements are presented by Hardy (1993), including storage criteria related to feed moisture levels. In particular, diets available for fish production fall into general categories based upon their general moisture content as follows: "dry" - less than 11% moisture; "semi-moist" - 12-16% moisture; and, "moist" - greater than 16% moisture (ibid.).

The majority of spring chinook reared at public fish culture facilities at the inception of YKFP facility planning (BPA 1990) were started and reared to approximately 400/lb using "closed-formula" semi-moist diets. The remainder of the production was commonly accomplished through the use of Oregon Moist Pellet (OMP;Hublou 1963) formulations following bid specifications. Use of semi-moist feed in full-term rearing of spring chinook salmon was limited and not fully evaluated at that time. Semi-moist diet trials had, however, provided favorable comparisons (growth, conversion, size variation, physiological measures) between spring chinook salmon reared on OMP and semi-moist diets (Hager et al. 1992). More recently, the use of a broader mix of closed formula moist, semi-moist, and dry diets with more general specifications has become the norm in chinook production (Kevin Amos, WDFW, pers. comm.).

Diet Recommendations for OCT-reared fish (ibid.) are:

- Start fry on moist or semi-moist diets.
- Rear juveniles on moist or semi-moist diets until approximately 1 gram average size.
- Complete rearing on OMP or similar project-specific formulations.

The upper Yakima spring chinook salmon production program will require approximately 97,000 pounds of feed annually. It is expected that diet procurement will follow state and federal fish culture nutritional specifications (State of Washington 1997; U.S. Fish and Wildlife Service 1997).

Feeding Methods: *experimental variable*

First feeding of spring chinook salmon will occur following yolk absorption when at least 90% of the population is free swimming (Fowler 1989). Approximately 1,665 temperature units at 50 F are required for chinook salmon fry development prior to the time of first feeding (Senn et al. 1984).

Fish feed is commonly delivered by hand and use of several types of feeders that have a wide range in complexity and application (ibid.). Fish will be fed following Piper et al. (1982) and Fowler (1989), at frequencies recommended by manufacturer's feeding tables, or as otherwise determined by project fish health/quality control staff.

Growth Schedule: controlled variable

The fish will be reared in concert with the planned temperature regime (BPA 1990) such that the projected growth schedule is followed and the desired size target is met at the appropriate time.

Pond Cleaning/Pollution Abatement: controlled variable

Pond cleaning will be a manual task. Typically, accumulated solids are removed by suction (vacuum) hose that discharges to an "off-line" pollution abatement system. Cleaning will be accomplished in a manner that will not condition fish to become attracted to large moving objects.

A "General Upland Fin-Fish Hatching and Rearing National Pollutant Discharge Elimination System (NPDES) Waste Discharge Permit" from the State of Washington Department of Ecology is required to operate fish culture facilities (Appendix D). This permit requires facilities using "off-line" waste treatment to monitor discharge to assure meeting discharge standards shown in Table 4 and the system performance criteria shown in Table 5.

Table 4. Effluent Limitations - Draft NPDES permit (ibid.: SII, A, 1a.).

Parameter	Monthly Average	Instantaneous Max.
Settleable Solids	0.1 (net ml/L)	
Total Suspended Solids	5.0 (net mg/L)	15 (net mg/L)

Table 5. Treatment system operational criteria - Draft NPDES permit (ibid.: SII, A, 2a.).

Parameter	Monthly Average	Instantaneous Max.
Settleable Solids (% removal)	90	
Total Suspended Solids		100 (mg/L)
Total Suspended Solids (% removal)	85	

Besides meeting the above-mentioned operational/performance criteria, the off-line system must be designed to provide 24 hours hydraulic retention for the cleaning system discharge (State of Washington 1990).

2. Acclimation Rearing

Following the preferred experimental design (Hoffman et al. 1994; Hopley 1995a), three acclimation sites with six ponds per site will be constructed. All ponds on each site will be supplied from a common water source and will represent each of the two treatments (OCT and SNT). Two of these sites will be located on the Yakima River between Ellensburg and Keechelus Dam and the other on the Teanaway River. The site selection process will consider biological and environmental criteria important to supplementation objectives.

Each acclimation pond will be sized to hold 45,000 spring chinook salmon (Hoffman et al. 1994; Hopley 1995a). These ponds will be of a common design with a rearing volume of approximately 4,500 ft^3 (BSWG 1994). They will be designed with operational flexibility sufficient to accommodate experimental design requirements and, by site, will have common water supplies and drains. Smolts exiting from the ponds will access the receiving water by the pond drain system. Predators will be controlled to assure fish inventory and experimental integrity.

Sites also feature security fencing and an alarm system with flow/level sensors. The security fencing will be installed to provide protection from furbearers and bird predation systems will be installed to assure inventory important to experimental needs. The pond outlet structure will be designed for electronic monitoring of outmigrants (smolts).

All ponds will be supplied with surface water with fluctuating temperature. Water delivery systems will use both pumped and gravity supplies.

These vessels will be in use from January through May. Following post-release cleaning, the ponds will be drained and allowed to stand dry until the next rearing cycle.

The OCT groups will be reared in acclimation ponds without any modifications thereby representing normal practices. Three of these groups will be represented in separate vessels within each of the acclimation sites to meet experimental design needs.

General Fish Culture: controlled variable

All acclimation ponds will be visited daily by project staff to assure project integrity and to do routine fish culture work (fish feeding, cleaning intake and outlet screens, verifying flow, recording temperature and other factors, etc.).

Rearing vessels will not be cleaned during use except as required for fish release. Dead fish will be removed and counted daily and otherwise processed as necessary to meet project objectives (saving fish for later tag recovery, etc.).

Because of the rearing density and anticipated low water temperatures, it is unlikely that disease treatment will be required during the acclimation and release phase of their culture. Any disease treatment, however unlikely, will be applied consistently with proper experimental methods.

Rearing Procedures: controlled variables

The planned maximum rearing density index for acclimation ponds is 0.11 lb/inch/ft^3 (BPA 1990). By mid-April, fish size is projected to be 15/lb attaining a peak acclimation pond loading of 3,000 pounds (BSWG 1994). Volitional outmigration is expected to offset any effect of increasing water temperature on the pond loading density through mid-May.

Fish will be fed daily by hand such that nutritional needs for health and growth are met. Sampling for size and consideration of water temperature profiles will provide the basis for reducing size variability across ponds and clusters of acclimation ponds.

Predator Control: controlled variable

Predation by birds and furbearers will be controlled by the construction of fencing and bird covers to assure control of population inventory and experimental integrity.

Monitoring: controlled variable

Pond level, inflow, and temperature will be monitored continuously by use of electronic technology (monitoring and telecommunication systems).

Pre-release Activities: controlled variables

Pre-release activities will involve pond cleaning next to the outlet one week prior to release to meet pollution discharge standards if pond levels are lowered to induce migration.

Post-release Activities: non-experimental

Post-release activities will involve removal of support equipment, pumps, intake screens, raceway outlet screens, stoplogs, and any other items that could be readily stolen or vandalized. All exposed supply and drain piping structures will be covered.

Additionally, the ponds will be cleaned and allowed to stand dry until the next rearing season. Pond cleaning will range from addition of commercially available bacterials for aerobic digestion of fish waste to physical removal of accumulated material.

On-site waste management opportunities will be developed in concert with the State of Washington Department of Ecology such that water quality standards are not compromised. If fish are released via pond drawdown, the following effluent limits apply (ibid.):

Parameter	Instantaneous Max.
Settleable Solids	1.0 ml/L
Total Susp. Solids	100 mg/L

Accumulated solids will be hauled off-site for disposal or must be otherwise processed "so as to prevent such materials from entering waters of the state" (ibid.). Senn et al. (1984) detailed concerns regarding the presence of the botulism organism, *Clostridium botulinum* (Type E), which may weigh against the use of fish pond waste as fertilizer. They further suggest that a fish health specialist be contacted regarding disposal of the sludge.

<u>Fish Transportation - Juveniles</u>: controlled variable

Spring chinook salmon juveniles will be transported from the Cle Elum Hatchery to acclimation ponds in January. Preliminary planning for the project envisioned the use of a variety of fish transportation systems (BPA 1990). Hauls from Cle Elum average 20 one-way miles (ibid.). Considering haul length and loading time, fish hauling time will probably not exceed 1.5 hours.

The recommended maximum loading rate for transporting spring chinook yearlings (15 fish/lb) is 1.0 pounds per gallon at 50°F (OPTT 1992). This rate is at the lower end of the range noted by Piper et al. (1982) for 15 fish/lb chinook salmon.

3. Research Support

<u>Fish Marking</u>: controlled variable

Knudsen (1993) summarized experimental and operational considerations associated with a wide variety of internal and external fish tags, visible implants, fin marks, and elemental scale marks. In addition to providing space for tag recovery as previously noted, hatchery facilities will also be designed to accommodate mobile marking units.

Use of rare earth or elemental solutions will require provisions for neutralization such as activated charcoal filters (ibid.).

<u>Fish Handling</u>: controlled variable

Juvenile fish handling will be accomplished using the method imposing the least stress or risk to fish health. Piper et al. (1982) noted the importance of assuring an adequate oxygen supply, a clean handling vessel and avoidance of over-loading nets and containers, water temperature shock, etc. Transport tank loading will be mechanized using fish pumps or Archimedes Screw technology.

Randomization

Zero-age fish, including family groups will be randomly distributed into each of the treatment sub-populations (treatment units) before placement into separate vessels (treatments). Randomization will occur at the eyed-egg stage concurrent with automated removal of dead eggs and enumeration of viable eggs. Use of automatic systematic random sampling equipment is envisioned (HOC, 1996).

4. Behavior Techniques: *experimental variable*

Does not apply.

5. Exercise: *experimental variable*

Does not apply.

6. Vessel Modifications

Raceway Color: *experimental variable*

Does not apply.

Overhead Cover: *experimental variable*

Does not apply.

In-water Structure: *experimental variable*

Does not apply.

Substrate: *experimental variable*
Does not apply.

Sub-surface Filtration: *experimental variable*

Does not apply.

B. Semi-Natural Treatment

"Semi-Natural Treatment - an experimental treatment that creates a more natural environment to incubate, rear, and acclimate fish. The intent of this treatment is to raise and release fish approximating the characteristics and behavior of their naturally produced counterparts." [1]

This section describes the Semi-Natural Treatment of planned upper Yakima River spring chinook salmon supplementation research. Nine groups of these fish will be reared from initial feeding through release under artificial production circumstances that have been modified physically and procedurally to fit experimental purposes (Hoffmann 1994; Hopley 1995a).

Initially anticipated experimental rearing and release methods and procedures are detailed below. Treatment features that were considered but not implemented in facility design or in the final operational plan are included and so noted.

1. Hatchery and Acclimation Rearing

As previously noted, the spring chinook salmon production goal of the Cle Elum Hatchery-based activities is 810,000 fish weighing 54,000 pounds. Rearing of the SNT portion (405,000 fish) will be accomplished with methods intended to allow enhancement of behavioral, morphological, and physiological characteristics that are important to survival.

<u>Rearing Density</u>: controlled variable

Since the benefits of lower rearing density on survival have been demonstrated (Banks 1990), and the project has chosen an optimal rearing density for OCT fish, the SNT fish will be reared at the same density as OCT fish in raceways and acclimation ponds.

<u>Rearing Vessels</u>: controlled variable

(see OCT)

<u>Inflow</u>: controlled variable

(see OCT)

<u>General Fish Culture</u>: controlled variables

Routine fish culture practices other than those discussed below will be standardized across all treatments.

<u>Fish Feed/Diet</u>: *experimental variable*

SNT fish diets will be supplemented with live organisms throughout their hatchery rearing period to condition released spring chinook salmon smolts to forage more effectively on naturally occurring food organisms. They will otherwise be fed with the OCT diet or possibly with an alternate prepared diet resembling the constituents of natural feed. Diets for SNT use will be manufactured following

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[1] "New Innovative Treatment" - Yakima/Klickitat Fisheries Project Planning Status Report 1992. Changed to "Semi-Natural Treatment" by the Monitoring Implementation Planning Team (Busack et al. 1997).

specifications that provide the desired nutrition requirements and appropriate feed delivery characteristics.

SNT fish will be fed caloric amounts equal to the OCT treatment group.

Note: This element was not implemented in the final experimental plan.

Feeding Methods: *experimental variable*

Pelletized feed will be introduced underwater from a specialized feeding system at a frequency appropriate to achieve proper growth.

The feeding system will consist of 5 feeding stations located along each SNT raceway wall and a continuous water supply used to deliver the feed to the fish. Each feeding station will be provided with a hopper for manual or mechanical addition of feed and two distribution tubes that discharge feed above the raceway bottom (Knudsen, 1997).

Growth Schedule: controlled variable

(see OCT)

Pond Cleaning/Pollution Abatement: controlled variable.

a. Raceways: Raceway cleaning will be a manual task. The raceway cleaning system will be designed to work effectively over natural substrates (by adaptation of normally provided equipment) or a flat surface and will not condition fish to seek moving objects.

b. Acclimation Ponds: Cleaning of substrate or flat surfaces will be by pump. Effluent will be discharged to a settlement vessel. Vessels will be cleaned as needed to maintain proper rearing conditions and to prepare the vessels for smolt release. It is expected that the latter activity will be limited to the area next to the outlet structure where settled solids could be disturbed with pond drawdown or increased exit velocity.

Fish Transportation - Juveniles: controlled variable

(see OCT)

Predator Control: controlled variable

(see OCT)

Predator avoidance training is discussed below.

Monitoring: controlled variable

(see OCT)

Pre-release Activities: controlled variables

(see OCT)

Post-release Activities: controlled variables

(see OCT)

2. Research Support

Fish Marking: controlled variable

(see OCT)

Randomization: controlled variable

(see OCT)

3. Behavior Techniques: *experimental variables*

Predator Avoidance Training: Avoidance training methodology will be applied to SNT experimental groups to allow fish to avoid predators. Fish will be trained to avoid predaceous fish, birds, and possibly mammals.

Conditioning may: (1) follow the approach of Thompson (1966) in which fish were trained with electrified model predators; (2) follow the approach of Olla and Davis (1989) in which fish were conditioned by exposure of fish to predators; or (3) be achieved by the placement of predators in cages in rearing vessels.

4. Exercise: *experimental variable*

Exercise is envisioned as a means of improving fish performance. This may be accomplished by the use of pumps or temporarily configuring vessel water supplies to create increased water velocities in raceways and acclimation ponds.

The planned exercise velocity will be one fish body length per second (Maynard 1993f).

Note: This element was not implemented in facility design.

5. Vessel Modifications: *experimental variable*

It is expected that standard raceways will be modified to improve fish quality and ultimately to achieve higher post-release survival ("quality").

Raceway Color

Donnelly (1992) and Maynard (in preparation) indicate that fish exposed to a rearing environment of the color matching that of the natural background of the area into which the fish will be released can be cryptically adapted. A period of at least seven weeks is required for full chromatophore expression.

Raceways will be modified to achieve the appropriate condition as determined by field use of colorimetric methods. The raceway walls will be painted to resemble stream background coloration.

Overhead Cover

Overhead cover will be applied at a covered-to-uncovered ratio of 4:1 (ibid.). Initial planning envisioned use of flat panels that would rest on vessel walls.

a. Raceways: Use of overhead cover will allow fish to become adapted to natural structures to avoid predation. It is expected that the effect of an undercut bank will be achieved by using 12 5 ft diameter floating hoops covered with camouflage netting per raceway (Knudsen, 1997).

b. Acclimation Ponds: Floating hoops will also be used to provide cover for acclimation ponds. The use of floating covers will facilitate fish culture activities and meet experimental needs as well.

In-water Structure

Use of in-water structures is envisioned to create a varied rearing environment in both raceways and acclimation ponds. It is expected that this denuded evergreen trees suspended off the bottom lengthwise bottom from a central cable will meet this need (ibid.).

Substrate

Vessels will be designed to allow randomization of vessels and substrate between years as required by experimentation. Space (0.5 ft) will be provided in each vessel to allow for the use of gravel or concrete panels. Use of a painted substrate has also been envisioned.

a. Raceways: The bottom of each SNT raceway will be painted with several colors using stencils simulating rock shapes.

b. Acclimation Ponds: Acclimation ponds will also be painted to simulate substrate.

Sub-surface Filtration

A rough substrate has the potential to collect settleable solids and improve environmental conditions within the formal rearing vessels through the actions of decay organisms.

a. Raceways: The bottom of each SNT raceway may be equipped with a substrate biological filtration system to enhance decomposition of organic materials that cannot be removed otherwise.

b. Acclimation: does not apply.

Note: This element was not implemented in the facility design and not included in the final experimental plan.

C. Limited Semi-Natural Treatment

This report section describes the Limited Semi-Natural Treatment, an alternate treatment that may eventually be tested with upper Yakima spring chinook salmon supplementation research. Nine groups of spring chinook salmon will be reared from incubation through transfer to acclimation ponds under normal artificial production (OCT)(Hoffmann 1994; Hopley 1995a). Their rearing will be completed in acclimation ponds under modified physical conditions identical to SNT procedures.

LSNT is an experimental treatment that creates a more natural environment in which to acclimate fish before release. The intent of this treatment is to determine if exposure of hatchery-reared fish to semi-natural conditions in the final phase of their rearing is sufficient to increase post-release survival.

1. Hatchery Rearing

As previously noted, the spring chinook salmon production goal of the Cle Elum Hatchery-based activities is 810,000 fish weighing 54,000 pounds. The production population will be separated into 18 treatment groups, nine of which could eventually be reared under standard (OCT) rearing conditions in raceways until transfer to acclimation ponds.

Except as noted under B (SNT) above, all variables associated with LSNT rearing will be controlled and identical to those discussed under A (OCT) above. As such, routine fish culture practices other than those discussed below will be standardized across all treatments.

Rearing Density: controlled variable

(see OCT)

Rearing Vessel: controlled variable

(see OCT)

Inflow: controlled variable

(see OCT)

General Fish Culture: controlled variables

(see OCT)

Fish Transportation - Juveniles: controlled variable

(see OCT)

Fish Feed/Diet: *experimental variable* - identical to OCT

(see OCT)

Feeding Methods, Growth Schedule: identical to OCT

(see OCT)

2. Acclimation Rearing

The LSNT groups will be separately reared in semi-natural (SNT) conditions in acclimation ponds. Rearing in acclimation ponds will be accompanied with methods intended to allow expression of behavioral, morphological, and physiological characteristics that are important to survival.

Except as noted under B (SNT) above, all variables associated with rearing will be controlled and identical to those discussed under A (OCT) above. Routine fish culture practices other than those discussed below will be standardized across all treatments.

<u>Fish Feed/Diet</u>: *experimental variable* - identical to SNT

<u>Feeding Methods</u>: *experimental variables* - identical to SNT

<u>Growth Schedule</u>: controlled variable - identical to OCT

3. Research Support

<u>Fish Marking</u>: controlled variable - identical to OCT

<u>Randomization</u>: controlled variable - identical to OCT

4. Behavior Techniques: *experimental variable*

Raceways: identical to OCT

Acclimation Ponds: identical to SNT

5. Exercise: *experimental variable*

Raceways: identical to OCT

Acclimation Pond: identical to SNT

6. Vessel Modifications: *experimental variable*

Raceway Treatment: identical to OCT

Acclimation Pond: identical to SNT

IV. STANDARD RELEASE TREATMENTS

Fish will be allowed to migrate volitionally from acclimation ponds and the ponds will be managed in terms of inflows and water levels to minimize residualizing fish.

Procedures

Smolt release procedures will follow the experience of WDFW in other upper Columbia drainages (primarily the Snake, Wenatchee, and Methow river systems). Generally, screens will be removed at the onset of migration to provide smolts an opportunity to migrate without interruption.

Enumeration

Migrating fish will be counted as they pass out of the acclimation ponds through or past sensing heads of electronic fish counters. The outlet structure design will reflect current management agency experience with fish counters (HOC 1996).

BIOLOGICAL SPECIFICATIONS FOR DESIGN

BIOLOGICAL SPECIFICATIONS FOR DESIGN

I. INTRODUCTION

Tables 1-3 (below) provide detailed biological, physical, and dimensional information which is necessary to advance the design process for upper Yakima spring chinook salmon production and related research facilities. The outline follows that of the preceding report from Adult Collection and Monitoring through Acclimation and Release.

Pertinent information is appended to facilitate understanding of technical aspects of the project and to meet design needs.

II. BIOLOGICAL SPECIFICATION TABLES FOR DESIGN

Table 1. Adult trapping, sorting, and transferring biological specifications for Upper Yakima spring chinook salmon.

Operating assumptions - adult trapping, sorting, and transferring:

- Normal operating mode: daily, per USBR/BPA agreement
- No. adults to retain and transfer: 1,110 fish
- Average weight per adult: 15 lb

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
SORTING AND ENUMERATION	SORTING VESSEL	Vessel Capacity	25 fish	as designed - 5' x 10' x 4' (depth)	6
		No. Vessels		as designed - 4 units	6
		Operational Period	May - September		4
		Vessel Volume	10 ft^3/ adult		6
		Flow Rate @ 50°F	1 gpm/adult: decrease loading by 5% per degree increase above 50°F	as designed - 2 gpm per adult	8
		Water Temperature	ambient		
		Water Dissolved Oxygen (minimum)	7.0 ppm		8
		Minimum Water Depth	5.0 ft.		8
	BROODSTOCK HOLDING VESSEL	Vessel Capacity	50 adults		6
		No. Vessels		1	6
		Operational Period	May - September		
		Vessel Volume	10 ft^3/adult		8
		Flow Rate @ 50°F	1 gpm/adult: decrease loading by 5% per degree increase		8
		Water Temperature	ambient		
		Water Dissolved Oxygen (minimum)	7.0 ppm		8

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
		Minimum Water Depth	5.0 ft.		
BIOLOGICAL PROCESSING	BIOLOGICAL PROCESSING AREA	Working Space	required		
		Anesthetic Type	tricaine methane sulfonate	130 - 260 mg/L of water.	11
		Antibiotic/Treatment	erythromycin phosphate, dorsal sinus injection	20 - 30 mg/adult	12, 13
BROODSTOCK ACQUISITION	TRAP, CROWDER	as designed	2 ft per second transport velocity	800 ft^3 capacity	5
	FISH LOCK, LIFT	as designed		per Bonneville Hatchery concept; 6 cfs maximum false weir flow	5
	SORTING FLUME	as designed		per Prosser design, with exit to river	5
	TAG DETECTION	as designed		space provided within the sorting flume	
	SORTING CELLS	as designed			5
	SCALLOPED BRAIL	as designed	20 fish capacity (approx.)	per Deschutes design (WDFW)	5
	CROWDERS	as designed		1 per channel, holding tank; 20 ft per minute travel rate	5
	ANESTHETIC TANK	as designed	aeration and cooling required	per Prosser design	5
	RECOVERY TANK	as designed	minimize descaling, bruising	smooth interior with river return line	5
	TANKER FILLING	as designed	on-site fish transport tanker filling capability required	river water provided	5
	INSTRUMENTATION AND CONTROL			monitoring and alarm system required for all elements	80
		Process Water:			
		a) Water Supply	required		
		b) Water Delivery	required		
		c) Temperature	local and remote monitoring required		

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
ADULT FISH TRANSFER	TANK LOADING HOPPER	Water-to-water transfer	minimize scaling, bruising	brail receptacle, tank drain	15
		Transfer Frequency	daily	up to 150	
		Maximum Number of Daily Trips	4 estimated at peak of run		92
		Haul Length		48 miles	4
		Transfer Tank Loading Rate:	1 lb per gallon a) decrease loading above 50°F b) decrease 10% each degree above 60°F c) reduce 50% for 30-40 lb fish		14
		Minimum Tank Size (working volume)	600 gallons (40 fish + displaced water)	min. 6" air space above the maximum working level	92
		Tank Discharge		rear gate	
		Tank Disinfection: a) Chlorine b) Iodophor	 100 ppm, 10 - 30 minutes 25 ppm, 10 - 30 minutes		17
		Disinfectant Neutralization: a) Chlorine b) Iodophor	 sodium thiosulfate clean water rinse	 4 grams per 5 gallons	17
	LIFE SUPPORT - ADULTS	Water Temperature Control	required; allowable variation - ± 2°F	by insulation or mechanical control	
		Water Tempering	required when change is 10°F	Ice must be chlorine free	14, 15
		Tank Ventilation	carbon dioxide removal	electrical aerators, venting	16
		CO_2 level - Maximum	less than 15 ppm		25

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
		Dissolved Oxygen - Minimum	80% of saturation or 7 ppm		16, 25
		Aeration:	oxygenation required	liquid or gas	16, 17
		a) Oxygen Source		bottled oxygen	17
		b) Oxygen Control		flow meters, manifold	17
		c) Oxygen Supply		50 psi	17
		d) Oxygen Delivery		carbon rod or ceramic diffuser	16, 17
		e) Carbon Rod Carrying Capacity	250 kg per meter		16
		Monitoring:	continuous	remote; equipment in transport vehicle cab	17
		a) Temperature	required		
		b) Dissolved Oxygen	required		
		Tank Loading Sight Gauge	required		17

Table 2a. Adult holding, spawning, incubation, and rearing biological specifications for Upper Yakima spring chinook salmon.

Operating assumptions - adult holding and spawning:

- Number of adult fish to collect, hold: 1,110
- Average size per adult: 15 pounds
- Number of females to spawn: 355
- Egg take: 1,242,000

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
ADULT HOLDING AND HANDLING	ADULT HOLDING VESSEL	Operational Period	mid-May through October		
		Adult Delivery to Pond	minimize descaling, bruising	by flume, align on long axis on deepest end	
		Number	provide treatment flexibility	2, identical	
		Flow	1 gpm/adult @ 50°F; increase 5% per each degree (F) increase above 50°F	1,110 gpm required @ 50°F	8
		Features:			
		a) Crowding, Sorting	required for spawning	to be determined	
		b) Group Separation	treatment by vessel		10
		c) Diffused Upwell	minimize jumping		8
		d) Overhead Spray	provide cover	complete surface disruption required	8
		e) Wet Surfaces	minimize physical damage	non-toxic, color to be determined	
		f) Fencing	minimize abrasion		8
		g) Freeboard	fish retention within vessel, safety		42
		Instrumentation and Control	life support; experimental integrity assurance		80
		Elements:			
		a) Water Supply	required	monitoring and alarm system required for elements a-e	
		b) Water Delivery	required		

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
		c) Pond Level	required		
		d) Water Temperature	required		
		e) Area Security	required	intruder detection system preferred	
		f) Area Lighting	all area lighting to be normally off during adult holding period	provide remote operation for security purposes	
		Vessel Depth	5 ft minimum		68
		Holding Volume	10 ft^3 per adult	11,100 ft^3 required	19, 77
		Water Temperature:			
		a) Range	43 - 58°F		24; 14, 25
		b) Pre-spawning Max	55°F (2 weeks before spawning)		25
		Water Quality:	per aquaculture standards, agency experience		20
		a) Total Dissolved Gases	<110% (nitrogen less than 103%)		73, 93
		b) Dissolved Oxygen - Discharge	7 ppm minimum		4, 8
		c) Re-use	2nd pass only, must meet oxygen, temperature, and fish health standards		4
		Broodstock Health Management	treatment as necessary to sustain broodstock	within-pond fish handling required	
		Fungus:			
		a) Fungicide	formalin, 1:6000	storage per MSDS, safety standards; maintain above freezing	12; 28
		b) Treatment	bath, every other day	remote delivery by pump; 1,900 gallons estimated annual use	12
		Systemic Pathogens:			13
		a) Antibiotic	erythromycin phosphate		12
		b) Treatment	injection, 23-30 mg antibiotic into dorsal sinus		12

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
	BIOLOGICAL PROCESSING AREA - PRE-SPAWNING	Operational Period	September - October	approx. 20' x 25', required adjacent to adult holding vessels	
	BIOLOGICAL PROCESSING AREA - PRE-SPAWNING	Features:	support for preparation of fish for spawning	non-porous, wet working surface required; process water required	
		a) Waste Management	control of spawning waste (blood, mucous, etc.)	handle/treat fish wastes per NPDES permit	32
		b) Disease Control	disinfection by iodophor, 50-100 ppm, neutralize with sodium thiosulfate	wash-down water required	32
SPAWNING/MATING	BIOLOGICAL PROCESSING AREA - SPAWNING	Operational Period	September - October	approximately 1,500 square ft required adjacent to Monitoring Support Laboratory and egg disinfection room	34
		Features:	support for technical and fish culture activities (use as storage area when not in use)	non-porous, wet working surface required; process water required	34
		a) Technical Support	fish handling equipment to be developed per need	electrical service, working area lighting, cover, wind protection required	34
		b) Waste Management	control of spawning waste (blood, mucous, etc.)	handle/treat spawning wastes per NPDES permit	32
		c) Disease Control	iodophor disinfection, 50-100 ppm, neutralize with sodium thiosulfate	wash-down water required	33
		d) Process Water	43 - 55°F; required to maintain temperature of pre-spawned carcasses, gametes	adult holding and incubation sources required for sprinklers, wash-down	
	MONITORING SUPPORT LABORATORY	Operational Period	all year	approx. 350 ft^2 required	
		Features:	fish health and biological sampling support	wet/dry laboratory required; equipment to be determined	
	CARCASS STORAGE AND DISINFECTION AREA	Operational Period:		approximately 30' x 50'	
		a) Carcasses	September - October		
		b) Equipment Disinfection	all year		
		Features:	fish health and operational support	non-porous, wet working surface required	34
		a) Disease Control	iodophor disinfection, 50-100 ppm, neutralize with sodium thiosulfate		

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
		b) Waste Management		handle/treat spawning wastes per NPDES permit	32

Table 2b. Adult holding, spawning, incubation, and rearing biological specifications for Upper Yakima spring chinook salmon.

<u>Operating assumptions - incubation</u>:

- Number of eggs to incubate: 1,242,000
- Incubation methods: common to all treatments
- Incubation system: isolation incubation, iso-buckets, vertical incubators
- Research support: supplementation, genetics (family research)

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
INCUBATION	DISINFECTION ROOM	Operational Period	all year with a September - October peak	wet area, approximately 20' x 30'; equipment/rainwear and safety gear storage required	
		Features:	egg disinfection and general sanitation support	sink with hot/cold potable water required	
		a) Egg Disinfection	iodophor, 50 - 100 ppm, neutralize with sodium thiosulfate	ventilation per safety standards required	33
		b) Waste Management	fish health management	handle/treat wastes per NPDES permit	32
		c) Storage		storage required for personal and protective clothing, disinfection and chemical use equipment	
		Troughs:	egg disinfection, water-hardening	16' x 2.5' x 2' (depth)	4
		a) No. Required	3		
		b) Flow per Trough	10 gpm		
		Water Source	pathogen-free, 38 - 55°F	well; incubation process water	41
INCUBATION THROUGH EYEING	INCUBATION ROOM	Operational Period	September - March	wet area, isolation from other rooms required	4, 37, 40
		Water Temperature:			
		a) Range	38 - 55°F	chilled source required	4
		b) Minimum - pre 128 cell stage	42.5°F		25
		c) Minimum - post 128 cell stage	35°F		25

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
		Water Quantity		see incubator and trough details	
		Water Quality:	per aquaculture, agency standards		20
		a) Dissolved Nitrogen	<103% saturation		8
		Iso-bucket Incubator:	used from water-hardening to eyed stage, approx. 450 temp. units	nested pair of buckets, 2 gallon size, approx. 9" (dia.) x 10 ", retained in troughs to control discharge	36
		a) Operational Period	September - December		4
		b) No. Required	444, 1 female (pairing) per bucket		
		c) Flow per Bucket	18 gph (0.3 gpm)		
		d) Water Delivery and Management	temperature controlled, monitored at mixing point	ambient and chilled sources to each trough	85
		Trough	used for discharge control during isolation incubation and for initial rearing of family research groups	16' x 2.5' x 2' (depth)	
		No. Required	30 initially, size for 50		75
		Incubation Use:			
		a) Operational Period	August - November		4
		b) Bucket Retention	22 iso-buckets per trough (discharge control)		
		c) Water Supply			
		Rearing Use:			10
		a) Operational Period	February - April		4
		b) Genetic Research	30 family groups, 1 per trough	provide space for 20 additional troughs	75
		c) Flow per Trough	10 gpm	incubation process water	82
		d) No. Fish per Trough	4,500 (largest expected &)		
		e) Rearing Density Index	.125 lb/ft^3/inch (body length)		

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
		f) Size at Marking	2.52 inches (60 mm)/200 fish per pound		
		f) Trough Loading at Marking and Transfer	20 pounds per trough; 2 lb/gpm		25
		Vertical Incubator	used from eyeing through swim-up; approx. 450 temp. units to hatch, 765 to ponding		8
		General:			4, 8
		a) Operational Period	November - March		
		b) Design Capacity	5,000 eggs per tray	16 trays per stack	8
		c) No. Trays Required	444 (1 per pairing)		
		d) No. Stacks Required	1 per treatment unit	24 stacks required	72, 74, 75
		e) Substrate	4 layers 1" extruded mesh		43
		f) Flow per Stack	10 gpm	chilled supply required	8
		g) Temperature Range	38 - 55°F		8
		h) Water Delivery and Management	manage temperature by "half-stack"	ambient and chilled sources to each trough per Eastbank design	42
		Fry Ponding Criteria:			43
		a) Ventral Slit Opening	1-3 mm		
		b) Condition Factor	KD = 1.97 - 2.10		
		Fish Health Management	treatment as necessary to assure egg survival		
		Fungus :			
		a) Fungicide	formalin	storage per MSDS; use per safety standards; maintain above freezing	
		b) Treatment	1:600-700 daily, 15 minute flush	remote delivery by gravity or pump	12

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
		Isolation Incubation Provisions:			40
		a) Footbaths	iodophor disinfectant, 50 - 100 ppm	required at each door	33
		b) Ventilation	prevent aerosol transfer	ventilation only to the exterior of the building; curtains at doors	
		Instrumentation and Control:	life support; experimental integrity assurance	monitoring and alarm system required for all elements noted	80
		a) Water Supply	all sources		
		b) Water Delivery	all vertical incubator head troughs, iso-bucket lines		
		c) Water Temperature	all sources		
		d) Incubation Room Lighting	on/off condition - light indication only		
		e) building security	intrusion alert		
BEHAVIORAL MONITORING	BEHAVIORAL MONITORING AREA	Research Area	fish behavior monitoring support	approximately 15' x 30' room with minimal intrusive activity required	
		Water Supply		50 gpm process water	
		Vessels		aquaria, window-ported troughs, etc..	

Table 2c. Adult holding, spawning, incubation, and rearing biological specifications for Upper Yakima spring chinook salmon.

Operating assumptions - hatchery rearing:

- Number of release groups: 18
- Number of fish per release group: 45,000
- Number of fish to transfer: 818,190
- Group weight at release: 15 fish per pound
- Number of smolts to be produced: 810,000

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
FACILITY SIZING	EXPERIMENTAL DESIGN	Number of Release Groups (Treatment Units)	18 (2 treatments, 9 replicates)		73, 74, 77
		No. Raceways per Treatment Unit	1		
		No. Raceways Required per Experimental Design	18		
		No. Raceways Required for Experimental Flexibility	2	flow will be provided from allocation for other vessels	77
		Total Number of Raceways Required	20		77
		SNT Treatment Requirements:	experimental variables apply to SNT groups only		
		a) Substrate (see h, below)	river rock matched to background color	mechanical installation and removal required annually	63
		b) Exercise	1 fish body length per second	0.5 ft per second	
		c) Predator Avoidance	provide learning experience	not specified; may require electrical service	
		d) Overhead Cover	simulate streambank conditions; 4:1 covered to uncovered ratio	not specified, may use covered frames	
		e) In-water Structure	simulate in-stream conditions	not specified	
		f) Feed Delivery	subsurface	not specified	
		g) Dissolved Oxygen	90% saturation throughout vessel (minimum)	not specified	
		h) Substrate Filtration	non-intrusive pond cleaning	0.5 ft to accommodate substrate and substrate filtration system	73

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
		Common Treatment Requirements:			
		a) Raceway Depth	3.5 ft per current practice (technology transfer)		51
		b) Randomization	annual, all groups, within raceways		74
		c) Yearling Transfer Period	January 1 - 31		45
		Predation Protection	protection of experimental integrity	fencing, physical barriers required	
		Fish Culture:			
		a) Temperature Units to First Feeding	1650		8
		b) Approximate Start of Feeding	mid-February		4
		c) Rearing Density Index	0.125 lb/ft^3/inch (body length)	0.75 lb/ft^3 maximum at end of rearing period	42
		Water Temperature Optimum Range	50 – 55°F		14
		Water Quality:	per aquaculture, agency standards		20
		a) Dissolved Nitrogen	<103% saturation	stabilize if more than 102% saturation	8
		b) Dissolved Oxygen	saturation	stabilize if less than 90% --------	8
		c) Dissolved Oxygen - Discharge	7 ppm minimum		4, 8
HATCHERY REARING	RACEWAY	Operational Period	all year	standard WDFW production vessel	
		Raceway Design:			
		a) Configuration	raceway: 30:3:1 (length:width:depth	100' x 10' x 3.5' (depth)	25
		b) Volume		3,500 ft^3	
		c) Interchange Rate	1.5 times per hour	650 gpm (1.44 cfs) per vessel	
		d) Supply Header	laminar flow required	full-width	

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
		e) Outlet Screen		full-width	
		f) Outlet System	experimental flexibility	infinitely variable standpipe	
		g) Surface Spill	surface film removal	outlet wall adjustable ports	
		h) Dividable Increments	operational and experimental flexibility	4 with equal intervals	
		i) Bottom Slope		0.5%	
		j) Freeboard	controlled variable - all groups	1.0 ft	73
		k) Sprinkler System	sunburn control	provide water supply, system to be retrofitted per experimental treatment	73
		l) Site Layout	separate, free standing, allowing "blocked " design;		52, 74
		m) Vessel Orientation	site specific, common to all vessels		86
		n) Vessel Arrangement	side by side in a single row		86
		Instrumentation and Control:	life support; experimental integrity assurance	monitoring and alarm system required for all elements noted	80
		a) Water Supply	all sources		
		b) Water Delivery	all vessels, by source		
GENERAL FISH CULTURE - FEEDING	FEED STORAGE	Operational Period	all year		
		Fish Feed, Diet:	per project nutritional and procurement specifications, including SNT specifications		
		A) Starter Diet		2,000 lb per year (approx.)	
		B) Production Diet		86,000 lb per year (approx.)	
		Storage Requirements:		controlled atmosphere, minimum temperature variation, vermin proofing, container stacking	55

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
		a) "Moist" Diet	> 16% total moisture	freezer required, -10°F	
		b) "Semi-moist" Diet	12-16% total moisture	refrigerated or dry storage required (cool, low humidity	
		c) "Dry" Diet	<11% total moisture	dry storage required (cool, low humidity)	
		Feeding Methods:			
		a) OCT	by hand		
		b) SNT	subsurface	not specified	
		c) LSNT	by hand at hatchery, subsurface during acclimation		
		Growth Schedule	per model		4
POND CLEANING	POLLUTION ABATEMENT SYSTEM	Operational Period	during fish rearing	per WDFW operating systems using suction to deliver solids to treatment vessels	
		Off-line System:			58
		a) Hydraulic Retention		24 hours minimum	32
		b) Settleable Solids		1.0 ml /l monthly average; 85% removal of total settleable solids	58
		c) Suspended Solids		100 mg/l monthly average; 15 mg/l instantaneous max.; 90% removal of total suspended solids	
		d) Waste Transport Velocity		>0.8 - 1.0 ft/sec	71
		In-line System:			53
		a) Hydraulic Retention		2 hours minimum	32
		b) Settleable Solids		1.0 ml /l monthly average	58
		c) Suspended Solids		100 mg/l monthly average; 15 mg/l instantaneous maximum	
JUVENILE FISH TRANSPORTATION	TRANSPORT TANK	Operational Period	peak use for transfer of yearling fish		4

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
		Transportation Requirements:	project support, general fish culture use		
		a) Number of Groups	18	approx. 3,000 lb/group	74, 75
		b) Average Haul Length - one way		20 miles	4
		Tank Loading Rate	size related, up to 1 lb/gal.	sight gauge required	17
		Life Support:			
		a) Temperature Control	required		
		b) Carbon Dioxide	<15 ppm	remove by ventilation, stripping agitators	14, 25
		c) Oxygen	>80% saturation; (7 ppm)		16, 25
		d) Oxygen Source		bottled gas	16, 17
		e) Oxygen Delivery	carbon rod, ceramic diffuser	via flowmeter at 50 psi	17
		f) Carbon Rod Carrying Capacity	250 kg/m		16
		Tank Disinfection	see Table 1		
		Monitoring:	continuous	remote; equipment in transport vehicle cab	15
		a) Temperature	required		
		b) Dissolved Oxygen	required		

Table 3. Acclimation and release biological specifications for Upper Yakima spring chinook salmon.

Operating assumptions - acclimation and release:

- Number of fish per release group: 45,000
- Size at release - weight: 15 fish per pound
- Size at release - length: 6.05 inches
- Group weight at release: 3,000 pounds
- Release timing: volitional, at onset of migratory behavior through May

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
SUPPLEMENTATION FACILITY SITING	SATELLITE SITES	Escapement Homing Target	appropriate spawning area/tributary		3
		Target Stream Flow	support all life stages, fish culture program	project to cause minimal bypass reach impact	
		Water Source a) General	target stream surface water	ambient, naturally variable	
		b) Growth	sufficient for growth during final 60 days of rearing (+37°F)		87
		c) Operations		sufficient to maintain process water flow under freezing conditions	
		Spawner Access to Target Area	from return through spawning		
		Spring Chinook Return timing	May through October		4
		Adult Holding Habitat	required May - October.		
FACILITY SIZING	EXPERIMENTAL DESIGN	Number of Release Groups (Treatment Units)	18 (3 sites, 2 treatments x 3 replicates)		73, 74, 75
		No. Vessels Per Treatment Unit	1		
		No. Sites Required	3		59, 73, 75, 76
		No. Vessels Per Site	6		73, 74
		Water Source	common to all vessels on site	naturally variable	
		Drain	common to all vessels	common open flume below outlet structure(s)	81

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
		Treatment Requirements:	SNT groups only	equipment support required annually	
		a) Randomization	annual, within each site vessels		
		b) Substrate	river rock (0.5-2”) matched to that of the release site	annual mechanical installation and removal of cast panels	63
		c) Exercise	1 fish body length per second	0.5 ft per second	63
		d) Predator Avoidance	provide learning experience		63
		e) Overhead Cover	simulate streambank conditions	floating hoops with camouflage covering to be used	87
		f) In-water Structure	simulate in-stream conditions	9-10 8ft evergreen trees per raceway: trees to be suspended on longitudinal cable(s) located beneath pond covers	87
		g) Feed Delivery	subsurface	5 stations per vessel side to be provided with process water for feed delivery	87
		h) Dissolved Oxygen	90% saturation throughout vessel (minimum)		
		Predation Protection	required to control inventory	fencing, other physical barriers	
		Fish Transfer Period	January 1 - 31		44, 45
		Winter Operations	vessels can freeze over		
ACCLIMATION REARING	VESSEL	Vessel Configuration:	raceway	provide research flexibility	81
		Raceway Design:			
		a) Length-Width Ratio	10:1		81
		b) Average Depth	4.5 ft	add 1.0 ft to raceway design	79
		c) Bottom Slope		0.5 ft per 100 ft	
		d) Vessel Orientation	site specific, common to all vessels		86
		e) Vessel Arrangement	side by side in a single row		86

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
		Water Delivery	1.5 interchanges per hour	provide manifold, moveable spout, flexibility in delivery	79, 81
		Operational Period	January - May		
		Water Temperature	33 - 55°F	ambient, variable	
		Water Quality:	per aquaculture standards		20
		a) Dissolved Gases - Water Supply	saturation		20
		b) Dissolved Oxygen - Discharge	7 ppm (OCT only)		4
		Water Quantity:	general - per FMC formula	adjust per altitude	4
		a) Per Vessel	840 gpm		79
		b) Per Site	5,040 gpm		79
		c) Per 3 sites	15,120 gpm		79
		d) Exercise	per experimental design criteria, above		81
		Rearing Density Index:	0.110 lb/cubic ft/inch (body length)		4
		a) Maximum loading at Release	0.66 lb/cubic ft	4,545 cubic ft per group (3,000 lb)	4, 79
		b) Minimum at Release	unknown, inversely related to density		62
		Instrumentation and Control:		project quality assurance	80
		a) Water Supply and Delivery		remote monitoring and alarm system required	
FISH ENUMERATION	RACEWAY OUTLET STRUCTURE		flexibility required to create proper exit conditions for fish release	per project recommendation	84
		Outlet Screen	required, exit velocity equal or less than hatchery raceways	equal or greater than 2 raceway screen equivalents (approx. 80 square ft)	81
		Release Method			
		a) Volitional	from onset of migratory behavior through May		

ACTIVITY	FACILITY COMPONENT	CRITERIA ITEM	BIOLOGICAL SPECIFICATIONS	PHYSICAL/DIMENSIONAL SPECIFICATIONS	REFERENCES
		b) Drawdown	as necessary to induce migration	step-wise capability required; accommodate inclined plane screen system	
		Fish Enumeration	required through migration period	electronic system to be used; flexibility required to create a wide range of exit conditions	81, 84
		Tag Detection	may be used - make provision in structure	detection heads to be placed in outlet structure	81
		Screen/Stop Log Guides		removable per design input	84
		Outlet Channel	vessels to discharge to an open channel	provide water level control structures as necessary	94
POND CLEANING	POLLUTION ABATEMENT SYSTEM	Operating Period	January - May	design as needed to meet permit requirements	32
		Pond cleaning:		design system as necessary	
		a) Rearing	vessels to be cleaned on an as-needed basis		
		b) Pre-release		outlet area to be cleaned prior to release	
		c) Post-release		solids and sludge to be removed from all vessels as necessary	
		Materials Disposal		accumulated materials to be taken off-site following on-site drying	
		Pond Drawdown - Fish Release Water Quality Standards:			32
		a) Settleable Solids		1.0 ml per liter (instantaneous maximum)	
		b) Suspended Solids		100 mg per liter (instantaneous maximum)	

ASSUMPTIONS AND RECOMMENDATIONS

ASSUMPTIONS AND RECOMMENDATIONS

Success of experimental objectives is premised on a suite of assumptions achieved through integration of biological specifications and experimental design. The underlying assumptions to this report are listed below and further categorized as to their status (Acceptable, Resolvable, and Unresolvable) and degree of uncertainty. Recommendations are listed separately and have been updated in light of project development that has occurred since the initial preparation of this document (September 1995).

I. ASSUMPTIONS

List Of Assumptions

1. Experimental methods and results of the Yakima Fisheries Project can be applied to the rebuilding and enhancement of other wild spring chinook stocks within the Columbia basin.

2. Measurable attributes (physiology, morphology, behavior, and survival) can be derived and used as specifications in comparing/evaluating and monitoring treatment groups (OCT, SNT, & LSNT) of the Yakima Fisheries Project.

3. Blocking of treatment groups can be accomplished throughout all captive life phases (broodstock collection/holding, incubation, rearing, and acclimation).

4. A Semi-Natural Treatment (SNT) for the culture and release of spring chinook can be described and applied to produce spring chinook that mimic specified characteristics (attributes/measures) of their natural counterparts.

5. A Limited Semi-Natural Treatment (LSNT) for the culture and release of spring chinook can be described and applied to meet the requirements of using OCT techniques through the rearing phase, and using SNT techniques during the acclimation phase.

6. An Optimal Conventional Treatment (OCT) for the culture and release of spring chinook can be described and applied to meet the requirements of using the optimal state-of-the-art artificial production techniques (during incubation, rearing and smolt acclimation phases), that are practiced within the Columbia basin.

7. Upper Yakima spring chinook can ascend the Roza fishway system and enter the adult collection facility without unnatural delay or behavior modification.

8. The Roza adult collection facility can be operated without causing either direct injury or delayed mortality/impairments to supplementation broodstock and naturally spawning spring chinook.

9. Broodstock can be selected and acquired at the Roza collection facility in manner that represents run timing, age, size, and sex composition of the Upper Yakima spring chinook.

10. Methods and procedures for transporting OCT, SNT and LSNT experimental groups (all life phases), to the Cle Elum and acclimation facilities are known, and can be applied without inducing significant mortality (direct or delayed) or unnatural behavior.

11. The spring chinook treated at the fish culture facilities will have minimum survival rates for broodstock holding at 80%, and fertilized egg - smolt at 65%.

12. An estimated mean fecundity of 3,500 eggs per female can be used for broodstock acquisition purposes.

13. The adult spring chinook holding volume of 10 ft^3 per adult is sufficient for fish health purposes, and will achieve an 80% survival rate for adults (collection through spawning).

14. The adult holding vessel inflow rate of 1.0 gallon per minute per adult, at 50°F, is sufficient for fish health purposes, and will achieve an 80% survival rate for adults (collection through spawning). The inflow rate is adjusted upward by 5% for each degree increase of water temperature above 50°F.

15. The quality and quantity of water sources (surface and ground) for the fish culture facilities are suitable and available for all experimental treatments of the supplementation project. All vessels at each site will be supplied from a common source.

16. The use of 2nd pass water in the Cle Elum facility is suitable for the holding of adult spring chinook broodstock, when water supply is limited.

17. Water temperature range of 43-50°F is suitable for fish health purposes, and will achieve an 80% survival rate for adults (collection through spawning).

18. Significant pathogens, monitoring methods, and treatments methods for said pathogens, that may affect experimental groups during all treatment phases are known.

19. Prophylactic methods and procedures for minimizing and containing diseases within experimental groups during all treatment phases are available for implementation.

20. The physical features of all experimental treatment facilities and ancillary components can be designed in a manner that reduces stress, injury, and mortality of experimental groups during all treatment phases.

21. Methods and procedures for randomizing of experimental OCT, SNT, and LSNT groups are known and available; randomization of experimental treatments can be applied to facilitate (a) the representative sample of phenotypic traits of the stock, and (b) statistical protocols for analyses/comparisons of treatment groups.

22. Materials, methods and procedures for discriminating treatment groups are available and can be applied during all treatment and post-treatment phases.

23. Water sources and temperature control are available at the Cle Elum facility and can be applied in regulating the rate of (a) embryonic development/time of fry emergence., and (b) fish growth.

24. The rearing density index of 0.125 lb per ft^3 per inch of body length (total length) for indoor rearing troughs is sufficient for fish health purposes, and will assist in achieving a fertilized egg - smolt survival rate of 65%.

25. Coded wire tags (CWT) can be applied to spring chinook at 200 fish per pound (~2.5" total length).

26. A maximum loading rate (biomass per unit flow) of 2.0 lb per gallon per minute(gpm) @ 50°F for indoor rearing vessels is sufficient for fish health purposes, and will assist in achieving a fertilized egg - smolt survival rate of 65%.

27. Fish physiology factors that affect smoltification and imprinting are known and require that all experimental treatment groups must be moved from the Cle Elum facility to acclimation satellites by no later than January 31 of each year in order to facilitate effective smoltification and homing (to release vicinity).

28. 15 fish per pound is considered the target size for Optimal Conventional Treatment smolts at time of release from the acclimation satellites and will provide an appropriate adult return to the Yakima Basin that can be statistically evaluated and compared to other treatments.

29. The maximum hatchery loading density of 0.75 and 0.66 lb of biomass per ft^3 for treatment in hatchery and acclimation raceways, respectively, is sufficient for fish health purposes and will assist in achieving a fertilized egg - smolt survival rate of 65%.

30. The length:width:depth ratio of 30:3:1 for treatment rearing vessels is sufficient for fish health purposes and will assist in achieving a fertilized egg - smolt survival rate of 65%.

31. Facilities and Operations Manuals that detail standard practices and procedures for treatment application can be developed and applied to all YFP facilities.

32. Nutritional requirements for all life phases (fry through smolt) of spring chinook are known and diets that fulfill these nutritional requirements either are available or can be developed. Methods and procedures for application of diets (formulated and live) to all treatments are known.

33. Fish culture methods and procedures for the semi-natural treatment (SNT) can be developed and applied in a manner that does not condition fish to exhibit unnatural behavior.

34. Acclimation rearing vessels will be supplied from a common water source. The surface water sources afford variable water temperatures.

35. Acclimation rearing vessels have identical dimensions, water volume, and flow rate.

36. The maximum rearing density index of 0.11 lb per inch (total length)/ft^3 for acclimation vessels is sufficient for fish health purposes and will assist in achieving a fertilized egg - smolt survival rate of 65%.

37. Release of OCT, SNT, and LSNT fish from acclimation satellites is volitional. Operational protocols volitional out-migration of spring chinook from the acclimation vessels to the receiving tributary waters are known and can be applied to the treatment groups.

38. Mortalities and injuries from predators can be controlled at all sites to assure experimental integrity.

39. Fish handling methods that reduce stress, injury, and mortality are known and will be applied.

40. Forage organisms and dietary composition for Upper Yakima spring chinook (juvenile and smolt) are known. Mimic or alternative diets for SNT groups that approximate natural forage organisms

(physical and nutritional attributes) can be produced and applied to stimulate natural-like foraging behavior.

41. Training methods and procedures for affecting predator avoidance behaviors of SNT groups are known and can be applied at the central and satellite facilities.

42. Exercise regimes for spring chinook fry, juveniles and smolts are known; and methods and procedures for applying exercise regimes to SNT groups, within rearing vessels of the central and satellite facilities are known and available.

43. Treatment specifications for cover and structure are known and will be applied to SNT groups.

44. Treatment specifications for substrate are known and will be applied to SNT groups.

45. A substrate biological filtration system for rearing vessels, at the Cle Elum facilities, is available and can be applied in a manner that enhance biological decomposition of waste materials (e.g. fish feces and residual feed).

46. Technologies for accurate enumeration of OCT, SNT, and LSNT experimental groups volitionally leaving acclimation vessels are known and can be applied to the YFP.

47. Coloration/background patterns of natural environs are known and can be applied to rearing vessels for SNT groups.

48. 48. SNT experimental variables are known and will not interact in manner that mask either positive or negative impacts/outcomes of each other.

Assumptions, Their Classification, Uncertainty, And Risk

Proposed New Assumptions		Acceptable (on what premise?)	Resolvable (Uncertainty)			Resolvable YFP Experiment	Unresolvable (Risk)		
No.	**Description**		**Low**	**Mod**	**High**		**Low**	**Mod**	**High**
1	Experimental methods and results of the Yakima Fisheries Project can be applied to the rebuilding and enhancement of other wild spring chinook stocks within the Columbia basin.	Yes (Biological Specifications Document: RASP & Treatment Definition)							
2	Measurable attributes (physiology, morphology, behavior, and survival) can be derived and used as specifications in comparing/evaluating and monitoring treatment groups (OCT, SNT, & LSNT) of the Yakima Fisheries Project.			Yes					
3	Blocking of treatment groups can be accomplished throughout all captive life phases (broodstock collection/holding, incubation, rearing, and acclimation).	Yes (Biological Specifications Document:- Treatment Definition)							
4	A Semi-Natural Treatment (SNT) for the culture and release of spring chinook can be described and applied to produce spring chinook that mimic specified characteristics (attributes/measures) of their natural counterparts.				Yes	Yes			
5	A Limited Semi-Natural Treatment (LSNT) for the culture and release of spring chinook can be described and applied to meet the requirements of using OCT techniques through the rearing phase, and using SNT techniques during the acclimation phase.				Yes	Yes			

Proposed New Assumptions		Acceptable (on what premise?)	Resolvable (Uncertainty)			Resolvable YFP Experiment	Unresolvable (Risk)		
No.	Description		Low	Mod	High		Low	Mod	High
6	An Optimal Conventional Treatment (OCT) for the culture and release of spring chinook can be described and applied to meet the requirements of using the optimal state-of-the-art artificial production techniques (during incubation, rearing and smolt acclimation phases), that are practiced within the Columbia basin.	Yes (Biological Specifications Document: Treatment Definition)							
7	Upper Yakima spring chinook can ascend the Roza fishway(s) and enter the adult collection facility without unnatural delay or behavior modification.		Yes						
8	The Roza adult collection facility can be operated without causing either direct injury or delayed mortality/impairments to supplementation broodstock and naturally spawning spring chinook.			Yes		Yes			
9	Broodstock can be selected and acquired at the Roza collection facility in manner that represents run timing, age, size, and sex composition of the Upper Yakima spring chinook.	Yes (Biological Specifications Document: GHG per Busack 1993)							
10	Methods and procedures for transporting OCT, SNT and LSNT experimental groups (all life phases), to the Cle Elum and acclimation facilities are known, and can be applied without inducing significant mortality (direct or delayed) or unnatural behavior.	Yes (Biological Specifications Document:- Treatment Definition)							
11	The spring chinook treated at the fish culture facilities will have minimum survival rates for broodstock holding at 80%, and fertilized egg - smolt at 65%.		Yes						

Proposed New Assumptions		Acceptable (on what premise?)	Resolvable (Uncertainty)			Resolvable YFP Experiment	Unresolvable (Risk)		
No.	Description		Low	Mod	High		Low	Mod	High
12	An estimated mean fecundity of 3,500 eggs per female can be used for broodstock acquisition purposes .	Yes (Biological Specifications Document: Knudsen 1992)							
13	The adult spring chinook holding volume of 10 ft^3 per adult is sufficient for fish health purposes, and will achieve an 80% survival rate for adults (collection through spawning)..	Yes (Biological Specifications Document:- Treatment Definition)							
14	The adult holding vessel inflow rate of 1.0 gallon per minute per adult, at 50°F, is sufficient for fish health purposes, and will achieve an 80% survival rate for adults (collection through spawning). The inflow rate is adjusted upward by 5% for each degree increase of water temperature above 50°F.	Yes (Biological Specifications Document:- Treatment Definition)							
15	The quality and quantity of water sources (surface and ground) for the fish culture facilities are suitable and available for all experimental treatments of the supplementation project. All vessels at each site will be supplied from a common source.				Yes				
16	The use of 2nd pass water in the Cle Elum facility is suitable for the holding of adult spring chinook broodstock, when water supply is limited.			Yes					
17	Water temperature range of 43-55°F is suitable for fish health purposes, and will achieve an 80% survival rate for adults (collection through spawning).	Yes (Biological Specifications Document: Literature References)							
18	Significant pathogens, monitoring methods, and treatments methods for said pathogens, that may affect experimental groups during all treatment phases are known.	Yes (Biological Specifications Document: Harrell 1993)							

Proposed New Assumptions		Acceptable (on what premise?)	Resolvable (Uncertainty)			Resolvable YFP Experiment	Unresolvable (Risk)		
No.	Description		Low	Mod	High		Low	Mod	High
19	Prophylactic methods and procedures for minimizing and containing diseases within experimental groups during all treatment phases are available for implementation.	Yes (Biological Specifications Document: Treatment Definition & Literature References)							
20	The physical features of all experimental treatment facilities and ancillary components can be designed in a manner that reduces stress, injury, and mortality of experimental groups during all treatment phases.			Yes		Yes			
21	Methods and procedures for randomizing of experimental OCT, SNT, and LSNT groups are known and available; randomization of experimental treatments can be applied to facilitate (a) the representative sample of phenotypic traits of the stock, and (b) statistical protocols for analyses/comparisons of treatment groups.	Yes (Biological Specifications Document: Busack and Hoffmann 1993/1994)							
22	Materials, methods and procedures for discriminating treatment groups are available and can be applied during all treatment and post-treatment phases.				Yes	Yes			
23	Water sources and temperature control are available at the Cle Elum facility and can be applied in regulating the rate of (a) embryonic development/time of fry emergence., and (b) fish growth.		Yes						
24	The rearing density index of 0.125 lb per ft^3 per inch of body length (total length) for indoor rearing troughs is sufficient for fish health purposes, and will assist in achieving a fertilized egg - smolt survival rate of 65%.	Yes (Biological Specifications Document: Treatment Definition)							

Proposed New Assumptions		Acceptable (on what premise?)	Resolvable (Uncertainty)			Resolvable YFP Experiment	Unresolvable (Risk)		
No.	Description		Low	Mod	High		Low	Mod	High
25	Coded wire tags (CWT) can be applied to spring chinook at 200 fish per pound (~2.5" total length).		Yes						
26	A maximum loading rate (biomass per unit flow) of 2.0 lb per gallon per minute(gpm) @ 50°F for indoor rearing vessels is sufficient for fish health purposes, and will assist in achieving a fertilized egg - smolt survival rate of 65%.	Yes (Biological Specifications Document: Treatment Definition)							
27	Fish physiology factors that affect smoltification and imprinting are known and require that all experimental treatment groups must be moved from the Cle Elum facility to acclimation satellites by no later than January 31 of each year in order to facilitate effective smoltification and homing (to release vicinity).				Yes	Yes			
28	15 fish per lb is considered the target size for Optimum Conventional Treatment smolts, at time of release from the acclimation satellites; and will provide an appropriate adult return to the Yakima Basin that can be statistically evaluated and compared to other treatments.	Yes (Biological Specifications Document: Treatment Definition)							
29	The maximum hatchery loading density of 0.75 and 0.66 lb of biomass per ft^3 for treatment in hatchery and acclimation raceways, respectively, is sufficient for fish health purposes and will assist in achieving a fertilized egg - smolt survival rate of 65%.	Yes (Biological Specifications Document: Treatment Definition)							
30	The length:width:depth ratio of 30:3:1 for treatment rearing vessels is sufficient for fish health purposes and will assist in achieving a fertilized egg - smolt survival rate of 65%.	Yes (Biological Specifications Document: Treatment Definition)							

Proposed New Assumptions		Acceptable (on what premise?)	Resolvable (Uncertainty)			Resolvable YFP Experiment	Unresolvable (Risk)		
No.	**Description**		**Low**	**Mod**	**High**		**Low**	**Mod**	**High**
31	Facilities and Operations Manuals that detail standard practices and procedures for treatment application can be developed and applied to all YFP facilities.		Yes						
32	Nutritional requirements for all life phases (fry through smolt) of spring chinook are known and diets that fulfill these nutritional requirements either are available or can be developed. Methods and procedures for application of diets (formulated and live) to all treatments are known.			Yes					
33	Fish culture methods and procedures for the semi-natural treatment (SNT) can be developed and applied in a manner that does not condition fish to exhibit unnatural behavior.				Yes	Yes			
34	Acclimation rearing vessels will be supplied from a common water source. The surface water sources afford variable water temperatures.			Yes					
35	Acclimation rearing vessels have identical dimensions, water volume, and flow rate.	Yes (Biological Specifications Document: Treatment Definition)							
36	The maximum rearing density index of 0.11 lb per inch (total length)/ft^3 for acclimation vessels is sufficient for fish health purposes and will assist in achieving a fertilized egg - smolt survival rate of 65%.	Yes (Biological Specifications Document: Treatment Definition)							

Proposed New Assumptions		Acceptable (on what premise?)	Resolvable (Uncertainty)			Resolvable YFP Experiment	Unresolvable (Risk)		
No.	Description		Low	Mod	High		Low	Mod	High
37	Release of OCT, SNT, and LSNT fish from acclimation satellites is volitional. Operational protocols volitional out-migration of spring chinook from the acclimation vessels to the receiving tributary waters are known and can be applied to the treatment groups.			Yes					
38	Mortalities and injuries from predators can be controlled at all sites to assure experimental integrity.			Yes					
39	Fish handling methods that reduce stress, injury, and mortality are known and will be applied.	Yes (Piper et al. 1982; Senn et al. 1984; Leitritz and Lewis 1980)							
40	Forage organisms and dietary composition for Upper Yakima spring chinook (juvenile and smolt) are known. Mimic or alternative diets for SNT groups that approximate natural forage organisms (physical and nutritional attributes) can be produced and applied to stimulate natural-like foraging behavior.				Yes	Yes			
41	Training methods and procedures for affecting predator avoidance behaviors of SNT groups are known and can be applied at the central and satellite facilities.				Yes	Yes			
42	Exercise regimes for spring chinook fry, juveniles and smolts are known; and methods and procedures for applying exercise regimes to SNT groups, within rearing vessels of the central and satellite facilities are known and available.				Yes				

Proposed New Assumptions		Acceptable (on what premise?)	Resolvable (Uncertainty)			Resolvable YFP Experiment	Unresolvable (Risk)		
No.	Description		Low	Mod	High		Low	Mod	High
43	Treatment specifications for cover and structure are known and will be applied to SNT groups.		Yes			Yes			
44	Treatment specifications for substrate are known and will be applied to SNT groups.		Yes			Yes			
45	A substrate biological filtration system for rearing vessels, at the Cle Elum facilities, is available and can be applied in a manner that enhance biological decomposition of waste materials (e.g., fish feces and residual feed).				Yes				
46	Technologies and procedures for accurate enumeration of OCT, SNT, and LSNT experimental groups, volitionally leaving acclimation vessels are known and can be applied to the YFP.			Yes		Yes			
47	Coloration/background patterns of natural environs are known and can be applied to rearing vessels for SNT groups.				Yes	Yes			
48	SNT experimental variables are known and will not interact in a manner that masks either positive or negative impacts/outcomes of each other.					Yes	Yes		

II. RECOMMENDATIONS

The Biological Specifications Work makes the following recommendations for work activities to be funded and undertaken in the near-term prior to initiating the operational phase of the Yakima spring chinook supplementation program; some of these work activities (Recommendations 10 and 11) would be continued and conducted within the context of the experimental program. Learning and information feedback within the supplementation program is a dynamic process that will provide information that can be used in the future refinement of treatment definition and description, and biological specifications for facilities components.

The recommendations are based on addressing critical uncertainties and risks associated with underlying assumptions supporting the treatment definitions and descriptions, and biological specifications set forth in the report. A recommendation specifies a general task activity or activities that would be undertaken in resolution of uncertainty. Each recommendation is ~~(1)~~ categorized according to a task listed in the 1993 Uncertainty Resolution Plan. Each recommendation is associated with assumptions noted previously.
LIST OF RECOMMENDATIONS

TROCT-1 (URP Task #4) and/or TRNITfin-1 (URP Task #7)

1. Provide target product specifications for the biological attributes of each treatment (Assumptions 2, 4, and #27.
2. Develop feed specifications for OCT and SNT pelletized feeds (Assumptions 32 and 40).

3. Determine the optimal type (species and quantity) of live feed diet (SNT) to condition spring chinook salmon to forage efficiently as wild fish (Assumptions 32 and 40).

4. Develop the training protocol to be used for conditioning spring chinook salmon to avoid predators (Assumptions 31, 33, 38, 41, and 47).

HAfin-1 (URP Task #14)

5. Test the utility of using an automated egg sorter/counter as a means of randomly developing treatment pairs (Assumption 21).

MARKMETHfin-1 (URP Task #35)

6. Complete assessment of marking methods required for discrimination of experimental treatments (Assumptions 22 and 46).

WATER-SOURCE-HAT-CLE ELUM (URP Task #138) and/or WATER-SOURCE-ACCL-UP-YAKIM (URP Task #244)

7. Confirm water quantity and quality availability at the Cle Elum facility meet the criteria set forth in the biological specifications document (Assumptions 15 and 23).

8. Perform routine measurements of water temperature and gas saturation at all surface water intakes of proposed fish culture facility sites (Assumption 15).

DESGN-HAT-CLE ELUM (URP Task #139) and/or DESGN-ACCL-UP-YAKIMA (URP Task #245)

9. Determine the fish enumeration system to be used to count smolts exiting the acclimation (Assumptions 22 and 46).

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